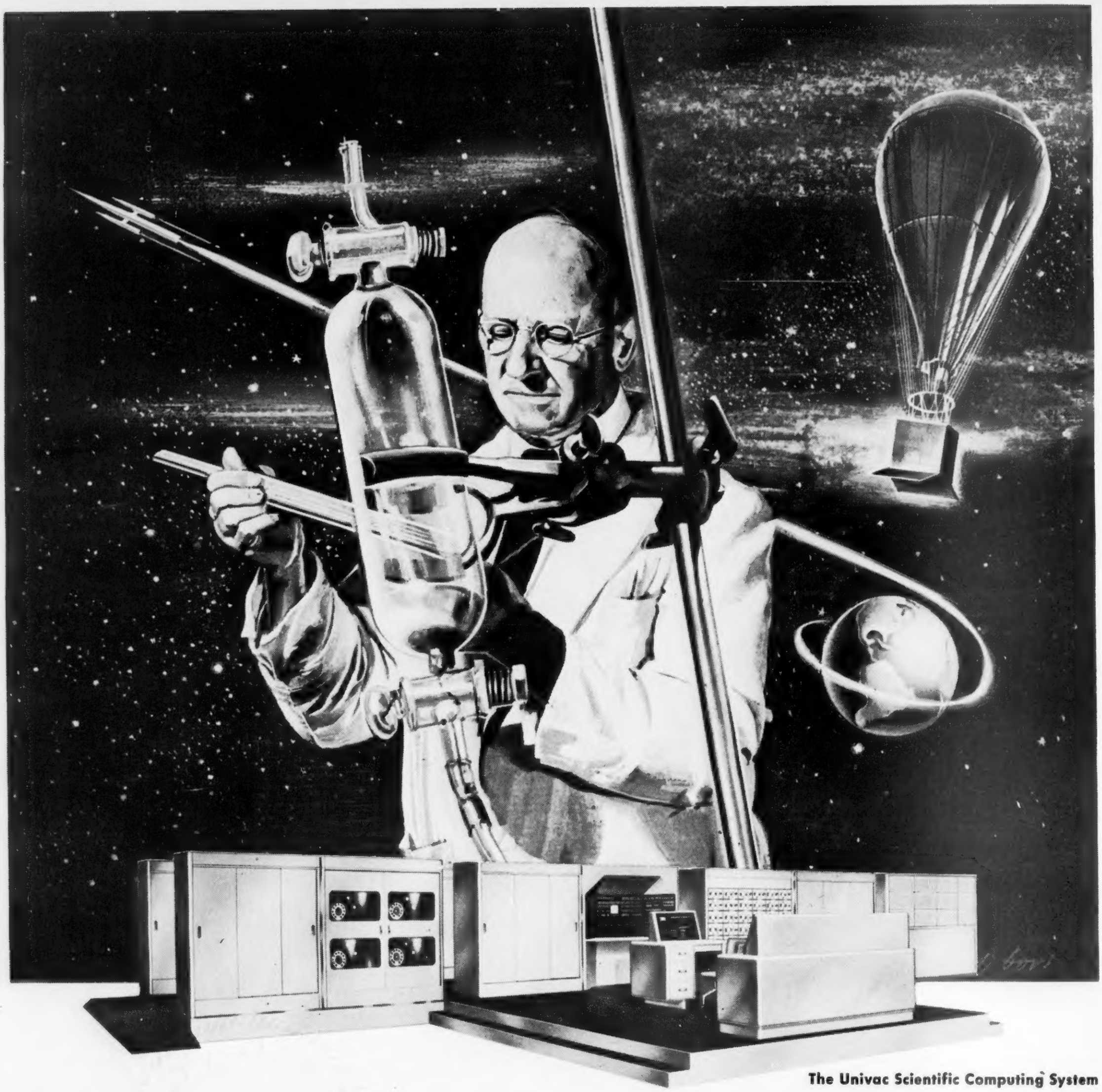
COMPUTERS AND AUTOMATION

YBERNETICS • ROBOTS • AUTOMATIC CONTROL



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COMPUTERS AND AUTOMATION

CYBERNETICS • ROBOTS • AUTOMATIC CONTROL

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THE EDITOR'S NOTES

SECOND EDITION OF THE

GLOSSARY

In this issue, we print in full a glossary of terms in the field of computers and automation. This is the second edition of the glossary published by COMPUTERS AND AUTOMATION. The first edition, now superseded, was published in three issues in 1953. This second edition is indebted to many sources, particularly to previously published glossaries, including one published in 1950 by the Institute of Radio Engineers, and one, dealing with digital computer programming terminology, by the Association for Computing Machinery in June, 1954, and to the following persons who have made contributions in one way or another: Grace M. Hopper, Alston S. Householder, D. R. Clutterham, James A. Pederson.

As usual, in the definitions printed in this glossary, we have tried to report meanings as used, rather than meanings which "should" be used.

Comments and criticisms of the definitions are invited, and will be appreciated, and probably will be published.

PUBLISHER OF "COMPUTERS AND AUTOMATION"

Beginning with the next issue, the publisher of COMPUTERS AND AUTOMATION " will be Berkeley Enterprises, Inc.: we are incorporating. The members of Edmund C. Berkeley and Associates will become members of Berkeley Enterprises. A majority of the stock of Berkeley Enterprises will be owned by Edmund C. Berkeley, who will be president of the corporation. The organization Edmund C. Berkeley and Associates will continue to exist for some purposes (particularly the courses by mail) but a great part of its operations will be transferred to Berkeley Enterprises.

We hope that among other things this step will make it possible for us to publish a larger, more useful, and better magazine.

GREETINGS

To all our readers, advertisers, and friends, we wish Christmas Greetings and a Very Happy New Year — from the staff of COMPUTERS AND AUTOMATION.

To those who enjoy puzzles, and particularly to computers, we express an additional greeting, appearing at the top of the next column.

GREETING TO COMPUTERS

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              M E R R Y
       times    X M A S
            -----------
              O R T E E Y
            L C R A A Y
          P L A T T Y
        O R T E E Y
        ---------------
     =  S L Y X M P M O Y,
  plus  S R E E A T X A Y C
        ---------------
     = P E A C E T O A L L      S I X = C I S
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and we wish you 32763 61456 38856 16513 4

Solve for the digits -- each letter stands for just one digit 0 to 9.

(This is a Numble; for hints for solution of this kind of puzzle, see our publication mentioned on p 39).

Forum: QUADRUPLED PRODUCTION
Bill Danch, Woodstock, N.Y.

"Are you the gentleman who is in the automation business?"

The Human Relations of Computers and Automation

Fletcher Pratt, New York
Author of 'Ordeal by Fire' and 30 other books

As automatic computers extend their operations into new fields of business and industry and the process of automation reaches new heights, there becomes visible an area of problems which as yet have received consideration chiefly by avoidance. This is the field of their human relations, particularly their labor relations, and the social changes that may be expected to follow from the new processes.

Technological Unemployment

Even the technological unemployment problem has been shuddered at rather than considered. A refinery in Canada is in an area which has no labor supply, and to which labor stoutly refuses to move because of the lack of creature comforts. This was anticipated by the builders of the refinery, and they very sensibly chose to make the operation as nearly fully automatic as possible, with a resultant saving of about 30% in the operating force needed. The plant is a success -- but the operating firm refuses to allow its name to be mentioned, presumably on the theory that it will have bad labor relations elsewhere as a result.

Similarly, many firms buying Univac time from Remington-Rand insist that their use of the computers be kept a secret. But it is difficult to see how the use of computers which only furnish data unobtainable by any other process, could be viewed by any reasonable person as threatening anyone's employment.

Reasonableness of Management and Labor

The answer probably is that management in such cases has a suspicion that labor will not be very reasonable in the face of innovations; and the suspicion is likely to be justified. The new photographic composing machines, made by manufacturers headed by Photon, largely have the simple 42-key typewriter keyboard and can be operated by any competent stenographer. The typographers promptly claimed jurisdiction over persons operating the new machines, which is within the normal pattern of labor relations. But they have also produced a mechanical monster called the Brewer keyboard to be attached to the photo machines. The Brewer enables the operator to punch things out on the elaborate 97-key linotype keyboard, from which they are translated electronically for the keyboard of the photo machine. The typographers consider this easier than spending two or three weeks to learn the simpler keyboard.

Neither labor nor management is squarely facing problems which can be solved only by the cooperation of both. Primarily this is a case of the narrow view. Of course, some kind of technological unemployment results from any new process: the invention of the automobile sensibly reduced the demand for blacksmiths, and that of the linotype for men who could set type by hand. But there is a difference. In the cases of automobile and linotype, the advance of the new devices was gradual and the bodies of labor affected were not the highly organized and vocal pressure groups of today.

Periodic Reeducation

The problem is likely to grow more acute with the advance of automation into new fields. Does it mean some kind of reorganization of industrial structure? It would be almost idle to predict, for the problem has not yet been submitted to enough study. It is possible that the solution will require going back to the level of the secondary schools and altering education. As now organized these schools tend to turn out specialists or at least people who will specialize at the next educative stage. Yet the demand of both automatic computers and an economy based on automation is for an immensely increased adaptability on the part of the individual. He must be willing not merely to accept periodic reeducation, but to regard it as a normal part of existence.

The Prospective Advance of Computing

The technological unemployment question is however only a single aspect of the new social complex inevitable as the result of computers and automation. There is a point at which any effort to hold back or contain a technical improvement becomes futile -- the point at which it becomes more profitable to violate any restriction than to conform to it. To observers living in the 19th century, the anti-machine riots in England appeared to demonstrate that the mechanization of industry would be achieved only slowly and with great difficulty. But the manifestations proved a wave on the surface only -- the appearance was illusory.

Modern counterparts of the machine-smashers can expect to achieve little more in the long run. The really important impact of the new methods will be felt when the use of computers is extended to take in the totality of a business or industrial operation instead of only some of its parts.

It is important to realize that computers today are as it were grafted onto industry and business, rather than built in as an integral part. There is no business in the United States today whose total structure has been set up with the use of computers as an essential part of the operation. Partly, no doubt, this is because the machines are so new; there has not been time for the growth of industries in which they perform a fully integrated function. Nor has programming progressed to the point where it is possible to instruct a computer on all the elements in a given industrial operation and expect an answer that will make managerial decisions almost unnecessary.

The Computation of Business Prospects

Things may never reach such a point; but it is quite clearly the direction in which the development is moving. By this I mean that we shall doubtless see the day when a man proposing to manufacture widgets will submit to a computer data covering his sources of raw material, machine and labor costs and supply, sales costs, outlets and localities, asking for a solution to the question where his plant should be located and how operated to achieve maximum efficiency. The idea is not exactly new; but as with the technological unemployment question, the consequences in the field of human relations have received little attention.

Or suppose, for example, that the manufacturer of widgets is already in business, with his factory, work force, and sales force. From the data submitted the computer draws one remorseless conclusion: the public has lost its taste for widgets and there is no longer any way to operate the factory at a profit. The information will certainly be not only unpalatable to the manufacturer, but also and still more so to the labor force. They are not going to take easily the idea of losing their jobs at the behest of a pile of wires and vacuum tubes. It may be that the plant can be used to manufacture gadgets instead of widgets, but the computer can hardly be expected to think of that unless programmed to consider it. And it is worth noting that this is not technological employment in the ordinary sense; it is something quite new, bound to make an impress on the national economy and social structure.

Computers and Size of Business

Equally striking is the deducible effect of computers on the size of business. Tenderness for the small, independent business man is one of the most cherished of American economic ideas, but the computers are facing him with a type of pressure he has never felt before. Without the use of computer time, he will in effect, be operating blind in competition with large organizations which can afford a lot of computer time, and which can effect enormous economies by an expenditure on computer time in three days of as much as the small business man makes in a month.

Perhaps small business men can form co-operatives to rent computer time, but until it has actually been done, this solution would appear of doubtful validity. The problems of a small business, its logistic support, and sales operations, are not very much less in complexity than those of a large one. Thus, relative to the scale of operations, the small business requires more computer time and computer expense than the larger one. It seems almost inevitable that computers as a factor in production will favor bigger business concentrations. It is not without significance that the greatest single employer of computers today is the biggest business of all -- the U. S. Government.

- END -

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Manuscripts. We desire to publish articles that are factual, useful, understandable, and interesting to many kinds of people engaged in one part or another of the field of computers and automation. In this audience are many people who have expert knowledge of some part of the field, but who are laymen in other parts of it. Consequently, a writer should seek to explain his subject, and show its context and significance. He should define unfamiliar terms, or use them in a way that makes their meaning unmistakable. He should identify unfamiliar persons with a few words. He should use examples, comparisons, analogies, etc., whenever they may help readers to understand a difficult point. He should give data supporting his argument and evidence for his assertions. An article may certainly be controversial if the subject is discussed reasonably. Ordinarily, the length should be 1000 to 4000 words, and payment will be $10 to $50 on publication. A suggestion for an article should be submitted to us before too much work is done. To be considered for any particular issue, the manuscript should be in our hands by the 5th of the preceding month.

Glossary of Terms in the Field of Computers and Automation

(Glossary, second edition, cumulative November 3, 1954)

The following is a glossary of terms used in the field of computers and automation. The purpose of this glossary is to report or indicate the meanings of terms as used. This glossary draws from previous glossaries, and from discussion of glossaries published in "Computers and Automation" and elsewhere. In general, the entry for any expression appears in alphabetic order according to the first word of the expression. For example "excess three code" appears under "e" for "excess" instead of "c" for "code".

Additions, comments, corrections, and criticisms will be appreciated.

A: absolute address -- Digital Computer Programming. The label assigned by the machine designer to a specific register or location in the storage.

absolute coding -- Coding that uses absolute addresses.

-ac -- An ending that means "automatic computer", as in Eniac, Seac, etc.

access time -- Digital Computers. 1. The time interval between the instant at which the arithmetic unit calls for information from the memory unit and the instant at which the information is delivered from storage to the arithmetic unit. 2. The time interval between the instant at which the arithmetic unit starts to send information to the memory unit and the instant at which the storage of the information in the memory unit is completed. -- In analog computers, the value at time t of each dependent variable represented in the problem is immediately accessible when the value of the independent variable is at time t, and otherwise not accessible.

accumulator -- Digital Computers. (1) A unit in a digital computer where numbers are totaled, that is, accumulated. (2) A register in the arithmetic unit of a digital computer where the result of arithmetical or logical operations is first produced. -- Often the accumulator stores one quantity and upon receipt of any second quantity, it forms the sum of the first and the second quantities and stores that instead. Sometimes the accumulator is able to perform other operations upon a stored quantity in its register such as sensing, shifting, complementing, etc.

accuracy — Correctness, or freedom from error. Accuracy contrasts with precision; for example, a four-place table, correctly computed, is accurate; while a six-place table containing an error is more precise but not accurate.

adder -- Computers. A device that can form the sum of two quantities delivered to it. Examples are: an accumulator; a differential gear assembly; etc.

address — Digital Computers. A label, name, or number identifying a register, a location, or a device where information is stored. See also: absolute address, floating address, relative address, symbolic address.

addressed memory -- Digital Computers. The sections of the memory where each individual register bears an address. -- In storage on magnetic tape, usually only blocks of a number of items of information have addresses, and an individual item does not have an individual address associated with it.

alphabetic coding -- A system of abbreviation used in preparing information for input into a machine, such that information may be reported not only in numbers but also in letters and words. For example, Boston, New York, Philadelphia, Washington, may in alphabetic coding be reported as BS, NY, PH, WA. Some computers will not accept alphabetic coding but require all abbreviations to be numerical, in which case these places might be coded as 0, 1, 2, 3.

analog -- Using physical variables, such as distance or rotation or voltage, or measurements of similar physical quantities, to represent and correspond with numerical variables that occur in a computation; contrasted with "digital".

analog computer -- A computer which calculates by using physical analogs of the variables. Usually a one-to-one correspondence exists between each numerical variable occurring in the problem and a varying physical measurement in the analog computer.

and -- Logic. A logical operator which has the property that if P and Q are two statements, then the statement "P AND Q" is true or false precisely according to the following table of possible combinations:

P	Q	P AND Q
false	false	false
false	true	false
true	false	false
true	true	true

The AND operator is often represented by a centered dot (·), or by no sign, as in P·Q, PQ.

'and' circuit -- Circuits. A pulse circuit with two input wires and one output wire, which has the property that the output wire gives a pulse if and only if both of the two input wires receive pulses. Also called a "gate" circuit.

arithmetic check -- A check of a computation, making use of arithmetical properties of the computation; for example, checking the multiplication A x B by comparing it with B x A.

arithmetic operation -- An operation in which numerical quantities form the elements of the calculation. Such operations include the "fundamental operations of arithmetic", which are addition, subtraction, multiplication and division.

arithmetic shift -- The multiplication or division of a quantity by a power of the base of nota-

tion. For example, since 1011 represents eleven in binary notation, the result of two arithmetic shifts to the left is 101100, which represents forty-four.

arithmetic unit -- Digital Computers. The section of the hardware of a computer where arithmetical and logical operations are performed on information.

asynchronous computer -- Digital Computers. An automatic computer where the performance of any operation starts as a result of a signal that the previous operation has been completed; contrasted with "synchronous computer", which see.

automatic carriage -- Punch Card Machines. A typewriting carriage which is automatically controlled by information and program so as to feed forms or continuous paper, space, skip, eject, tabulate, etc. It may produce any desired style of presentation of information on separate forms or on continuous paper.

automatic checking -- Computers. Provision, constructed in hardware, for automatically verifying the information, transmitted, manipulated or stored by any device or unit of the computer. Automatic checking is "complete" when every process in the machine is automatically checked; otherwise it is partial. The term "extent of automatic checking" means either (1) the relative proportion of machine processes which are checked, or (2) the relative proportion of machine hardware devoted to checking.

automatic computer -- A computer which automatically handles long sequences of reasonable operations with information.

automatic controller -- A device which controls a process by (1) automatically receiving measurements of one or more physical variables of the process, (2) automatically performing a calculation, and (3) automatically issuing suitably varied actions, such as the relative movement of a valve, so that the process is controlled as desired; for example, a flyball governor on a steam engine; an automatic pilot.

automatic programming -- Digital Computer Programming. Any technique whereby the computer itself is used to transform programming from a form that is easy for a human being to produce into a form that is efficient for the computer to carry out. Examples of automatic programming are compiling routines, interpretive routines, etc.

automation -- 1. Process or result of rendering machines self-acting or self-moving; rendering automatic. 2. Theory or art or technique of making a device or a machine or an industrial process more fully automatic. 3. Making automatic the process of moving pieces of work from one machine tool to the next.

available machine time -- Time that a computer has the power turned on, is not under maintenance, and is known or believed to be operating correctly.

average calculating operation -- A common or typical calculating operation longer than an addition and shorter than a multiplication; often taken as the mean of nine additions and one multiplication.

B: base -- Numbers. Ten in the decimal notation of numbers, two in the binary notation of numbers, eight in octal notation, and in general the radix in any scale of notation for numbers.

binary -- Involving the integer two. For example, the binary number system uses two as its base of notation. A binary choice is a choice between two alternatives; a binary operation is one that combines 2 quantities.

binary cell -- An element that can have one or the other of two stable states or positions and so can store a unit of information.

binary-coded decimal notation -- One of many systems of writing numbers in which each decimal digit of the number is expressed by a different code written in binary digits. For example, the decimal digit zero may be represented by the code 0011, the decimal digit one may be represented by the code 0100, etc.

binary digit -- A digit in the binary scale of notation. This digit may be only 0 (zero) or 1 (one). It is equivalent to an "on" condition or an "off" condition, a "yes" or a "no", etc.

binary notation -- The writing of numbers in the scale of two. The first dozen numbers zero to eleven are written 0, 1, 10, 11, 100, 101, 110, 111, 1000, 1001, 1010, 1011. The positions of the digits designate powers of two; thus 1010 means 1 times two cubed or eight, 0 times two squared or four, 1 times two to the first power or two, and 0 times two to the zero power or one; this is equal to one eight plus no four's plus one two plus no ones, which is ten.

binary number -- A number written in binary notation.

binary point -- In a binary number, the point which marks the place between integral powers of two and fractional powers of two, analogous to the decimal point in a decimal number. Thus, 10.101 means four, one half, and one eighth.

binary to decimal conversion -- The mathematical process of converting a number written in binary notation to the equivalent number written in the ordinary decimal notation.

biquinary notation -- Numbers. A scale of notation in which the base is alternately 2 and 5. For example, the number 3671 in decimal notation is 03 11 12 01 in biquinary notation; the first of each pair of digits counts 0 or 1 units of five, and the second counts 0, 1, 2, 3, or 4 units. For comparison, the same number in Roman numerals is MMMDCLXXI. Biquinary notation expresses the representation of numbers by the abacus, and by the two hands and five fingers of man; and has been used in some automatic computers.

bit -- A binary digit; a smallest unit of information; a "yes" or a "no"; a single pulse in a group of pulses.

block -- Digital Computers. A group of consecutive machine words considered or transferred as a unit, particularly with reference to input and output.

bootstrap -- Digital Computer Programming. The coded instructions at the beginning of an input tape, together with one or two instructions inserted by switches or buttons into the computer, used to put a routine into the computer.

break-point -- Digital Computer Programming. A point in a routine at which the computer may, under the control of a manually set switch, be stopped for an operator's check of the progress of the routine.

buffer -- Circuits. 1. An isolating circuit used to avoid any reaction of a driven circuit upon the corresponding driving circuit. 2. A cir-

cuit having an output and a multiplicity of inputs so designed that the output is energized whenever one or more inputs are energized. Thus, a buffer performs the circuit function which is equivalent to the logical "or", which see.

buffer storage — Digital Computers. 1. Equipment linked to an input device, in which information is assembled from external storage and stored ready for transfer to internal storage. 2. Equipment linked to an output device into which information is transmitted from internal storage and held for transfer to external storage. Computation continues while transfers between buffer storage and external storage take place.

buss — Digital Computers. A path over which information is transferred, from any of several destinations; a channel, line, or trunk.

<u>C</u>: call-number -- Digital Computer Programming. A set of characters identifying a subroutine, and containing information concerning parameters to be inserted in the subroutine, or information to be used in generating the subroutine, or information related to the operands.

call-word -- Digital Computer Programming. A call-number which fills exactly one machine word.

capacity — Digital Computers. 1. The number of digits or characters which may regularly be processed in a computer, as in "the capacity of the computer is ten decimal digit numbers". 2. The upper and lower limits of the numbers which may regularly be handled in a computer, as "the capacity of the computer is + .00000 00001 to .99999 99999". Quantities which are beyond the capacity of the computer usually interrupt its operation in some way.

card -- Computers. A card of constant size and shape, adapted for being punched in a pattern which has meaning. The punched holes are sensed electrically by wire brushes or mechanically by metal fingers. Also called "punch card." One of the standard punch cards (made by International Business Machines Corporation) is 7 and 3/8 inches long by 3 and 1/4 inches wide, and contains 80 columns in each of which any one of 12 positions may be punched.

card column — Punch Card Machines. One of a number of columns (45, 80, or 90) in a punch card into which information is entered by punches.

card feed — Punch Card Machines. A mechanism which moves cards one by one into a machine.

card field — Punch Card Machines. A set of card columns fixed as to number and position, into which the same item of information is regularly entered; for example, purchase order numbers of five decimal digits might be punched regularly into the card field consisting of card columns 11 to 15.

card stacker -- Punch Card Machines. A mechanism that stacks cards in a pocket or bin after they have passed through a machine. Sometimes called "card hopper".

card reader — Punch Card Machines. A mechanism that causes the information in cards to be read, usually by passing them under copper wire brushes or across metal fingers.

card punch — Punch Card Machines. A mechanism which punches cards, or a machine which punches cards according to a program.

carry — Arithmetic. 1. The digit to be taken to the next higher column (and there added) when the sum of the digits in one column equals or exceeds the number base. 2. The process of transferring the carry digit to the next higher column.

cathode ray tube -- Digital Computers. A large electronic vacuum tube containing a screen on which information, expressed in pulses in a beam or ray of electrons from the cathode, is stored by means of the presence or absence of spots bearing electrostatic charges. The capacity usually is from 256 to 1024 spots.

cell -- Digital Computers. Storage for one unit of information, usually one character or one machine word. More specific terms ("column, location, block") are preferable since there is little uniformity in the use of the term "cell".

channel — Digital Computers. 1. A path along which information, particularly a series of digits or characters or units of information, may flow or be stored. For example, in the machine known as a punch card reproducer, information (in the form of punch cards) may flow in either one of two card channels which do not physically connect. 2. Magnetic Tape or Magnetic Drums. A path parallel to the edge of the tape or drum along which information may be stored by means of the presence or absence of polarized spots, singly or in sets. 3. Delay Line Memory such as a Mercury Tank. A circular path forward through the delay line memory and back through electrical circuits along which a pattern of pulses representing information may be stored.

character -- Digital Computers. 1. A decimal digit 0 to 9, or a letter A to Z, either capital or lower case, or a punctuation symbol, or any other single symbol (such as appear on the keys of a typewriter) which a machine may take in, store, or put out. 2. A representation of such a symbol in a pattern of ones and zeros representing a pattern of positive and negative pulses.

check digit -- One or more digits carried along with a machine word (i.e., a unit item of information handled by the machine), which report information about the other digits in the word in such fashion that if a single error occurs (excluding two compensating errors), the check will fail and give rise to an error alarm signal. For example, the check digit may be 0 if the sum of other digits in the word is odd, and the check digit may be 1 if the sum of other digits in the word is even.

circulating memory — Digital Computers. A device using a "delay line" which stores information in a train of pulses or waves, as a pattern of the presence or absence of such pulses, where the pattern of pulses issuing at the final end of the delay line is detected electrically, amplified, reshaped, and reinserted in the delay line at the beginning end.

closed subroutine -- Digital Computer Programming. A subroutine with the following properties: (1) it is stored separately from the main routine; (2) at the proper point in the main routine, a jump instruction transfers control to the beginning of the subroutine; (3) at the end of the subroutine, another jump instruction transfers control back to the proper point in the main routine.

clear (verb) — Digital Computers. To replace information in a register by zero as expressed in the number system employed.
code (noun) — Computers. A system of symbols for representing information in a computer and the rules for associating them.
code (verb) — Computers. To express information, particularly problems, in language acceptable to a specific computer.
coded decimal (adjective) — Computers. A form of notation by which each decimal digit separately is converted into a pattern of binary ones and zeros. For example, in the "8-4-2-1" coded decimal notation, the number twelve is represented as 0001 0010 (for 1, 2) whereas in pure binary notation it is represented as 1100. Other coded decimal notations are known as: "5-4-2-1", "excess three", "2-4-2-1", etc.
coded decimal digit — A decimal digit which is expressed by a pattern of four or more ones and zeros.
coded program — A program which has been expressed in the code for a computer.
coder — A person who translates a sequence of instructions for an automatic computer to solve a problem into the precise codes acceptable to the machine.
coding — The list in computer code of the successive computer operations required to carry out a given routine or subroutine or solve a given problem.
coding line — A single command or instruction written usually on one line, in a code for a computer to solve a problem.
collate — To combine two sequences of items of information in any way such that the same sequence is observed in the combined sequence. For example, sequence 12, 29, 42 and sequence 23, 24, 48 may be collated into 12, 23, 24, 29, 42, 48. More generally, to combine two or more similarly ordered sets of items to produce another ordered set composed of information from the original sets. Both the number of items and the size of the individual items in the resulting set may differ from those of either of the original sets and of their sums.
collator — Punch Card Machines. A machine which has two card feeds, four card pockets, and three stations at which a card may be compared or sequenced with regard to other cards, so as to determine the pocket into which it is to be placed. The machine is particularly useful for matching detail cards with master cards, for merging cards in proper sequence into a file of cards, etc.
column — 1. Writing. The place or position of a character or a digit in a word, or other unit of information. 2. Computers. One of the characters or digit positions in a positional notation representation of a unit of information. Columns are usually numbered from right to left, zero being the rightmost column if there is no decimal (or binary, or other) point, or the column immediately to the left of the point if there is one. 3. Arithmetic. A position or place in a number, such as 3876, written in a scale of notation, corresponding to a given power of the radix. The digit located in any particular column is the coefficient of the corresponding power of the radix; thus, 8 in the foregoing example is the coefficient of 10^2.
command — A pulse, signal, or set of signals initiating one step in the performance of a computer operation.
comparator — 1. Circuits. A circuit which compares two signals and supplies an indication of agreement or disagreement; or a mechanism by means of which two items of information may be compared in certain respects, and a signal given depending on whether they are equal or unequal. 2. Computers. A device for comparing two different transcriptions of the same information to verify agreement or determine disagreement.
comparison — Computers. The act of comparing and, usually, acting on the result of the comparison. The common forms are comparison of two numbers for identity, comparison of two numbers for relative magnitude, and comparison of two signs plus or minus.
compiler — Digital Computer Programming. A program-making routine, which produces a specific program for a particular problem by the following process: (1) determining the intended meaning of an element of information expressed in pseudo-code; (2) selecting or generating (i.e., calculating from parameters and skeleton instructions) the required subroutine; (3) transforming the subroutine into specific coding for the specific problem, assigning specific memory registers, etc., and entering it as an element of the problem program; (4) maintaining a record of the subroutines used and their position in the problem program; and (5) continuing to the next element of information in pseudocode.
compiling routine — Computers. A routine by means of which a computer can itself construct the program to solve a problem by assembling, fitting together, and copying other programs stored in its library of routines. Same as "compiler", which see.
complement — Arithmetic. A quantity which is derived from a given quantity, expressed in notation to the base n, by one of the following rules. (a) Complement on n: subtract each digit of the given quantity from n-1, add unity to the rightmost digit, not zero and perform all resultant carries. For example, the twos complement of binary 11010 is 00110; the tens complement of decimal 679 is 321. (b) Complement on n-1: subtract each digit of the given quantity from n-1. For example, the ones complement of binary 11010 is 00101; the nines complement of decimal 679 is 320. The complement is frequently employed in computers to represent the negative of the given quantity.
complete operation — Computers. A calculating operation which includes (1) obtaining all the numbers entering into the operation out of the memory, (2) making the calculation, (3) putting the results back into the memory, and (4) obtaining the next instruction.
computer — 1. A machine which is able to calculate or compute, that is, which will perform sequences of reasonable operations with information, mainly arithmetical and logical operations. 2. More generally, any device which is capable of accepting information, applying definite reasonable processes to the information, and supplying the results of these processes.
computing machinery — Machinery which is able to

take in and give out information, perform reasonable operations with the information, and store information.

computer code — Computers. The code expressing the operations built into the hardware of the computer.

computer operation — Computers. The electronic, mechanical, or other physical operation of hardware in a computer resulting from an instruction to the computer.

conditional — Computers. Subject to the result of a comparison made during computation; subject to human intervention.

conditional breakpoint instruction -- Digital computer Programming. A conditional jump instruction which, if some specified switch is set, will cause the computer to stop, after which either the routine may be continued as coded or a jump to another routine may be directed.

conditional transfer of control — Digital Computers. A computer instruction which when reached in the course of a program will cause the computer either to continue with the next instruction in the original sequence or to transfer control to another stated instruction, depending on a condition regarding some property of a number or numbers which has then been determined.

contents — Digital Computers. The information stored in any part of the computer memory. The symbol "(...)" is often used to indicate "the contents of..."; for example, (m) indicates the contents of the storage location whose address is m.

control (verb) -- Digital Computers. To direct the sequence of execution of the instructions to a computer.

control circuits — Digital Computers. The circuits which effect the carrying out of instructions in proper sequence.

control register -- Digital Computers. The register which stores the current instruction governing the operation of the computer for a cycle.

control sequence -- Digital Computers. The normal sequence of selection of computer instructions for execution. In some computers, one of the addresses in each instruction specifies the control sequence. In most other computers the sequence is consecutive except where a jump occurs.

control unit — Digital Computers. That portion of the hardware of an automatic digital computer which directs the sequence of operations, interprets the coded instructions, and initiates the proper signals to the computer circuits to execute the instructions.

converter -- A machine which changes information in one kind of language acceptable to a machine into corresponding information in another kind of language acceptable to a machine. For example, a machine which takes in information expressed in punch cards and produces the same information expressed in magnetic tape, is a "converter". Often the machine possesses limited computing facilities, spoken of as "editing facilities".

copy — Digital Computers. To transfer information stored in one memory register into another memory register, leaving unchanged the information in the first register, and replacing whatever was previously stored in the second register.

counter — A mechanism which either totals digital numbers, or allows digital numbers to be increased by additions of one in any column of the number. It is also able to be reset to zero.

crippled leap-frog test — Digital Computer Programming. A variation of the leap-frog test described below, modified so that it repeats its tests from a single set of storage locations and does not "leap".

cybernetics — 1. The study of control and communication in the animal and the machine. 2. The art of the pilot or steersman. 3. The comparative study of complex information-handling machinery and the nervous systems of the higher animals including man in order to understand better the functioning of brains.

cycle (verb) -- Computers. To repeat a set of operations a specified number of times including, when required, supplying necessary memory location address changes by arithmetic processes or by means of a hardware device such as a cycle-counter.

cycle (noun) — 1. A set of operations repeated as a unit. 2. Computers. The smallest period of time or complete process of action that is repeated in order. In some computers, "minor cycles" and "major cycles" are distinguished. 3. Computer Arithmetic. A shift of the digits of a number such that digits removed from one end of the word are inserted in sequence at the other end of the word, in circular fashion.

cycle criterion -- Digital Computer Programming. The total number of times that a cycle is to be repeated, or the register which stores that number.

cycle index — Digital Computer Programming. The number of times a cycle has been executed; or the difference (or the negative of the difference) between that number and the number of repetitions desired.

cycle reset -- Digital Computer Programming. The returning of a cycle index to its initial value.

cyclic shift — Computer Arithmetic. A shift of the digits of a number (or the characters of a word) in which digits removed from one end of the word are inserted in the same sequence at the other end of the word, in circular fashion.

<u>D</u>: DC dump -- Digital Computers. The condition resulting when direct current power is withdrawn from a computer which uses volatile storage, i.e., loss of information stored in such storage.

debug — Computers. To isolate and remove malfunctions from a computer or mistakes from a program.

decade -- A group of ten; for example, a "decade counter" will count to ten in one column or place of a decimal number.

decimal digit -- One of the symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 when used in numbering in the scale of ten. Two of these digits, 0 and 1, are of course also binary digits when used in numeration in the scale of two.

decimal notation -- The writing of quantities in the scale of ten.

decimal point -- In a decimal number, the point

that marks the place between integral and fractional powers of ten.

decimal-to-binary conversion -- Mathematical process of converting a number written in the scale of ten into the same number written in the scale of two.

delay line -- Computers. A device which stores information in a train of pulses or waves, and as a pattern of the presence or absence of such waves. An example of a delay line in everyday life is an echo; the air and a reflecting wall momentarily store a train of sound waves. In a computer delay line, the medium may be mercury, the container a pipe, and the pulses issuing at the final end may be detected electrically, amplified, reshaped, and reinserted at the beginning end.

diagnostic routine -- Digital Computer Programming. A specific routine designed to locate either a malfunction in the computer or a mistake in coding.

diagram — Digital Computer Programming. A schematic representation of a sequence of subroutines designed to solve a problem. It is a less detailed and less symbolic representation than a flow chart, and frequently includes descriptions in English words.

differential analyzer -- An analog computer designed particularly for solving or "analyzing" many types of differential equations.

differentiator -- Analog Computers. A device whose output signal is proportional to the derivative of an input signal.

digit — 1. One of the symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, used in numbering in the scale of ten. 2. One of these symbols and sometimes also letters expressing integral values ranging from 0 to n-1 inclusive, used in a scale of numbering to the base n.

digital — Using numbers expressed in digits and in a scale of notation, in order to represent all the variables that occur in a problem.

digital computer -- A computer which calculates using numbers expressed in digits and yeses and noes expressed usually in 1's and 0's, to represent all the variables that occur in a problem.

digitize — To change an analog measurement of a physical variable into a number expressed in digits in a scale of notation.

double precision — Digital Computers. Having twice as many digits as the quantities normally handled in the computer. For example, in the case of a desk calculator regularly handling ten place decimal numbers, computation with 20 place numbers by keeping track of the 10 place fragments, is "double precision" computation.

down-time -- Computer Operation. Time when a computer is malfunctioning, or not operating correctly, due to machine failure.

dummy -- Digital Computer Programming. An artificial address, instruction, or other unit of information inserted solely to fulfill prescribed conditions (such as word-length or block-length) without affecting operations.

dump -- Computer Operation. To withdraw all power accidentally or intentionally.

duplication check — A check which requires that the results of two independent performances (either concurrently on duplicate equipment or at a later time on the same equipment) of the same operation be identical.

dynamic storage -- Storage such that information at a certain position is changing over time and so is not always available instantly; for example, acoustic delay line storage or magnetic drum storage.

dynamic subroutine -- Digital Computer Programming. A subroutine which involves parameters, such as decimal point position or item size, from which a relatively coded subroutine is derived. The computer itself is expected to adjust or generate the subroutine according to the parametric values chosen.

E: edit — Digital Computer Programming. To arrange or rearrange information for the output unit to print. Editing may involve the deletion of unwanted data, the selection of pertinent data, the insertion of invariant symbols such as page numbers and typewriter characters, and the application of standard processes such as zero-suppression.

education of a computer — Computers. Preparing and assembling programs for a computer so that the computer can itself put together many programs for many purposes. This greatly reduces the time required from human programmers to program the computer.

electric typewriter — A typewriter having an electric motor and the property that almost all the operations of the machine after the keys are touched by human fingers are performed by electric power instead of the power of human fingers and hands.

electronic (as contrasted with "electric") — In general, dealing with flows of small numbers of electrons in a vacuum, as contrasted with flows of large numbers of electrons along wire conductors.

electronic calculating punch — Punch Card Machines. A punch card machine which, in each fraction of a second reads a punch card passing through the machine, performs a number of sequential operations, and punches a result on the punch card.

electrostatic storage -- Storage of information in the form of the presence or absence of spots bearing electrostatic charges. See "cathode ray tube".

equation solver -- A computing device, often analog, which is designed to solve systems of linear simultaneous (nondifferential) equations or find the roots of polynomials, or both.

equivalent binary digits -- Number of binary digits equivalent to a given number of decimal digits or other characters. When a decimal number is converted into a binary number, the number of binary digits necessary is in general equal to about 3 1/3 times the number of decimal digits. In coded decimal notation, the number of binary digits necessary is ordinarily 4 times the number of decimal digits.

erasable storage -- Storage media which can be erased and reused; for example, magnetic tapes.

erase -- Digital Computers. 1. To remove information from storage and leave the space available for recording new information. 2. To replace all the binary digits in a storage device by binary zeros. In a binary computer, erasing is equivalent to clearing, while in a coded decimal computer where the pulse code for decimal zero may contain binary ones, clear-

ing leaves decimal zero while erasing leaves all-zero pulse codes.

error — The amount of loss of precision in a quantity; the difference between an accurate quantity and its calculated approximation. Errors occur in numerical methods; mistakes occur in programs, coding, data transcription, and operating; malfunctions occur in computers.

excess-three code — A coded decimal notation for decimal digits which represents each decimal digit as the corresponding binary number plus three. For example, the decimal digits 0, 1, 8, 9, are represented as 0011, 0100, 1011, 1100, respectively. As may be seen, in this notation, the nines complement of the decimal digit is equal to the ones complement of the corresponding four binary digits.

exchange — Digital Computer Programming. To interchange the contents of two storage devices or locations.

executive routine — Digital Computer Programming. A routine designed to process and control other routines.

external memory — Digital Computers. Materials separate from the computer itself but holding information stored in language acceptable to the machine, as for example, recorded magnetic tape in a closet, or punch cards in filing cabinets.

extract — Computers. 1. To obtain certain digits from a machine word as may be specified. For example, if the ten digit number 0000011100 is stored in a machine register, the computer can be instructed to "extract" the eighth digit (in this case a one) and correspondingly perform a certain action. 2. Computers. To replace the contents of specific columns of one machine word by the contents of the corresponding columns of another machine word, depending on the instruction. 3. To remove from a set of items of information all those items that meet some arbitrary condition.

F: field — 1. Punch Card Machines. A set of one or more columns in each of a number of punch cards which is regularly used to report a standard item of information. For example, if columns 16 to 19 are regularly used to report weekly rate of pay, then these columns would constitute a field. 2. Computers. A set of one or more characters (not necessarily all lying in the same word) which is treated as a whole; a unit of information.

fixed-cycle operation — Computers. Organization of a computer whereby a fixed time is allocated to operations, although they may actually take less time than is allocated. This is the type of operation of a "synchronous" computer.

fixed-point calculation — Computers. Calculation using or assuming a fixed or constant location of the decimal point or the binary point in each number.

fixed-point representation — Arithmetic. An arithmetical notation in which all numerical quantities are expressed by the same specified number of digits, with the point implicitly located at the same specified position.

flip-flop — Circuits. An electronic circuit having two stable states, two input lines, and two corresponding output lines such that a signal exists on either one of the output lines if and only if the last pulse received by the flip-flop is on the corresponding input line.

floating-point calculation — Computers. Calculation taking into account varying location of the decimal point (if base 10) or binary point (if base 2), and consisting of writing each number by specifying separately its sign, its coefficient, and its exponent affecting the base. For example, in floating-point calculation, the decimal number -638, 020, 000 might be reported as -,6.3802,8, since it is equal to -6.3802×10^8.

flow chart — Digital Computer Programming. A graphical representation of a sequence of programming operations, using symbols to represent operations such as compute, substitute, compare, jump, copy, read, write, etc. A flow chart is a more detailed representation than a diagram, which see.

force (verb) — Digital Computer Programming. To intervene.

four-address (adjective) — Digital Computer Programming. Having the property that each complete instruction specifies the operation and the addresses of four registers. Usually each instruction contains the addresses of three operands (i.e., the numbers being operated with), the operation, and the address of the next order.

function switch — Circuits. A network or circuit having a number of inputs and outputs and so connected that signals representing information expressed in a certain code, when applied to the inputs, cause output signals to appear which are a function of the input information.

function table — 1. Mathematics. A table of the values for a mathematical function. 2. Computers. A hardware device or a program which translates from one representation of information to another representation.

G: gate — Circuits. An electronic circuit with two inputs and one output, which has the property that a pulse goes out on the output line if and only if some specified combination of pulses occurs on the two input lines. The combination may be the presence of pulses on both input lines, which is called an "and" gate, or the presence of a pulse on one line and the absence of a pulse on the other line, which is called an "except" gate or inhibitory gate.

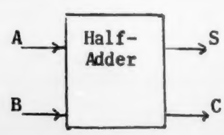
general routine — Digital Computer Programming. A routine expressed in computer coding designed to solve a class of problems, specializing to a specific problem when appropriate parametric values are supplied.

generate — Digital Computer Programming. To produce coding by assembling and modifying primitive elements; similar to generation of a line by a point, a plane by a line, etc.

generator — Digital Computer Programming. A computer program which generates coding.

H: half-adder — Circuits. A circuit having two output channels for binary signals (either zero or one) in which the output signals are related to the input signals according to the following table:

Input A	Input B	Output S	Output C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1



This circuit expresses in hardware a part of the functions necessary for binary addition. The letter S stands for "sum without carry"; the letter C stands for "carry". With two half-adders, and another circuit properly transferring the carry from one column to the next column, a circuit which will perform binary addition can be constructed.

hardware -- Computers. The mechanical, magnetic, electrical, and electronic devices from which a computer is constructed.

head -- Computers. Same as "magnetic head", a small electromagnet used for reading, recording or erasing polarized spots on a magnetic surface.

hold -- Computers. To retain the information contained in one storage device after copying it into a second storage device. Opposed to "clear".

holding beam — Computer Circuits. A diffuse beam of electrons for regenerating the charges stored on the dielectric surface of an electrostatic memory tube or cathode ray storage tube.

I: ignore (noun) -- Output Devices. A typewriter character indicating that no action whatsoever be taken. In the system of coding punched in Teletype of Flexowriter paper tape, the character "all holes punched" is an ignore.

infinity — Computers. Any number larger than the maximum number that the computer is able to store in any register. When such a number is calculated, the computer usually stops and signals an alarm indicating an overflow.

information -- 1. A set of marks or an arrangement of hardware that has meaning or that designates one out of a finite number of alternatives. 2. Any facts or data.

information word -- Computers. 1. Machine word. 2. The information content of a machine word. A machine word often includes the separating space between it and the following (or preceding) word.

inherited error -- Machine Computation. The error in the initial values, especially the error accumulated from the previous steps in a step-by-step integration.

input -- Computers. Information transferred from secondary or external storage into the internal storage of the computer.

input block -- Computers. A section of the internal storage reserved for receiving and processing input data.

input equipment — Computers. The equipment used for taking information into a computer.

input unit -- Computers. The unit which takes into the computer information from outside the computer.

instruction — Computers. A machine word or a set of characters in machine language which directs the computer to take a certain action. More precisely, a set of characters which defines an operation together with one or more addresses (or no address) and which, as a unit, causes the computer to operate accordingly on the indicated quantities. Note: The term "instruction" is preferred by many to the terms "command" and "order"; "command" is reserved for electronic signals; "order" is reserved for uses in the meaning "sequence", as in "the order of the characters".

instruction code -- Digital Computer Programming. The system of symbols, names, and definitions of all the instructions that are directly intelligible to a given computer or a given executive routine.

integrator -- Analog Computers. A device whose varying output is proportional to the integral of a varying input magnitude.

interlace -- Computers. To assign successive memory location numbers to physically separated memory locations on a magnetic drum, for example, in such a way that access time to successive memory locations is greatly reduced.

internal memory -- Computers. The total memory or storage which is accessible automatically to the computer without human intervention. This equipment is an integral physical part of the computer and is directly controlled by the computer.

internal storage -- Computers. Same as internal memory, which see.

interpreter -- Digital Computer Programming. An executive routine which, as the computation progresses, translates a stored program expressed in some machine-like pseudo-code into machine code and performs the indicated operations, by means of subroutines, as they are translated. An interpreter is essentially a closed subroutine which operates successively on an indefinitely long sequence of program parameters (the pseudo-instructions and operands). It may usually be entered as a closed subroutine and left by a pseudo-code exit instruction.

interpreter code -- A code acceptable to an "interpreter", which see.

interpretive routine -- Same as "interpreter", which see.

item -- 1. A separate piece of information; a separate particular. 2. Digital Computer Programming. A group of fields reporting information about a person or object. An example of an item is a punch card punched with employee's name in columns 1 to 12, employee number in columns 13 to 15, weekly rate of pay in columns 16 to 19, and other standard information about the employee in other columns.

J: jump — Digital Computer Programming. An instruction or signal which, conditionally or unconditionally, specifies the location of the next instruction and directs the computer to that instruction. A jump is used to alter the normal sequence in the control of the computer. Under certain special conditions, a jump may be caused by the operator's throwing a switch.

K: key -- Digital Computer Programming. A set of characters, forming a field, used to identify an item.

L: latency -- Digital Computer Programming. Delay while waiting for information called for from the memory to be delivered to the arithmetical unit. More specifically, in a serial storage system, latency is the access time minus the word time. For example, latency is the time spent waiting for the desired memory location to arrive under the heads on a magnetic drum.

leapfrog test — Computer Operation. A program to test the internal operation of a computer,

characterized by the property that it performs a series of arithmetical or logical operations on one section of memory locations, then transfers itself to another section, checks to see that the transfer is correct, and then begins the series of operations over again. Eventually the checking program will have occupied every possible position in the memory and will begin again. The term "leapfrog" comes from the indicated jump in the position of the checking routine as seen on a monitoring cathode ray tube when it transfers itself.

library — Digital Computer Programming. A collection of standard and fully tested programs, routines, and subroutines, by means of which many types of problems and parts of problems can be solved.

line-a-time printing — Printing of a whole line of characters at one time, usually by means of one typebar (bearing all characters) for each character space in the line.

location -- Digital Computers. A storage position in the main internal storage or memory, storing one computer word; a storage register.

logic — Computers. In the phrase "logic of the computer", same as "logical design", which see.

logical comparison -- Logic. The operation of comparing A and B; the result is 1 or yes if A is the same as B and 0 or no if A is not the same as B (or vice versa).

logical design -- Computers. Design that deals with the logical and mathematical interrelationships that must be implemented by the hardware.

logical operations -- Computers. The operations of comparing, selecting, making references, matching, sorting, merging, etc., where in essence ones and zeros corresponding to yeses and noes constitute the elements (yes-or-no quantities) being operated on.

loop -- Digital Computer Programming. Repetition of a group of instructions in a routine.

M: machine cycle -- Computers. The smallest period of time or complete process of action that repeats itself in order. In some computers, "minor cycles" and "major cycles" are distinguished,

machine language -- Computers. Information in the physical form which a computer can handle. For example, punched paper tape is machine language, while printed characters on paper are not usually machine language.

machine word -- Digital Computers. A unit of information of a standard number of characters, which a machine regularly handles in each register. For example, a machine may regularly handle numbers or instructions in units of 36 binary digits: this is then the "machine word".

magnetic core -- Computers. A form of storage where information is represented as the polarization north-south or south-north of a wire-wound magnetically permeable core, which may be straight, doughnut-shaped, etc.

magnetic drum -- Computers. A rapidly rotating cylinder, the surface of which is coated with a magnetic material on which information may be stored as small polarized spots.

magnetic head -- Computers. A small electromagnet used for reading, recording, or erasing polarized spots on a magnetic surface.

magnetic memory — Computers. Any portion of the memory which makes use for storage of the magnetic properties of materials.

magnetic tape -- Tape made of paper, metal or plastic, coated or impregnated with magnetic material, on which polarized spots representing information may be stored.

magnetic wire -- Wire made of magnetic material on which polarized spots representing information may be stored.

major cycle -- Computers. In a memory device which provides access to storage positions one after another, the time interval between successive appearances of the same storage position. In other words, this is the time for one rotation of a magnetic drum or one recirculation of pulses in a delay line. It is an integral number of minor cycles.

malfunction -- Computers. A failure in the operation of the hardware of a computer.

marginal checking -- Computer Circuits. A system of designing electronic circuits so that the voltage of the heaters of the tubes, ordinarily established at 6.3 volts, may be lowered if desired to 5 or 4.7 volts, and the circuits then tested to determine if they still continue to operate satisfactorily.

master clock — Computers. The primary source of timing signals.

mathematical check -- A check making use of mathematical identities or other properties. For example, multiplication may be verified by the mathematical check that A multiplied by B is the same as B multiplied by A, the two multiplications being performed at different times and compared with each other. Frequently a small degree of discrepancy is acceptable; this is referred to as the tolerance.

mathematical lógic -- Exact reasoning about nonnumerical relations using symbols that are efficient in calculation. Also called "symbolic logic".

mercury memory -- Digital Computers. Delay lines using mercury as the medium for storage of a circulating train of waves or pulses.

memory -- Computers.1. The units which store information in the form of the arrangement of hardware or equipment in one way or another. Same as "storage". 2. Any device into which information can be introduced and then extracted at a later time.

memory capacity -- The amount of information which a memory unit can store. It is often measured in the number of decimal digits or the number of binary digits which the memory unit can store. Other measures of memory capacity have also been defined.

mercury tank -- A container of mercury holding one or more delay lines storing information.

merge -- To produce a single sequence of items, ordered according to some rule (i.e., arranged in some orderly sequence), from two or more sequences prveiously ordered according to the same rule, without changing the items in size, structure, or total number. Merging is a special case of collating.

message — A group of words, variable in length, transported as a unit.

microsecond -- A millionth of a second.

millisecond -- A thousandth of a second.

minimum access programming -- Digital Computer Programming. Programming in such a way that

minimum waiting time is required to obtain information out of the memory. Also called "minimum latency programming", or "forced coding".

minimum access routine -- Digital Computer Programming. In a computer with a serial memory, a routine coded with judicious arrangement of data and instructions in such a way that actual waiting time for information from the memory is much less than the expected random access waiting time.

minimum latency programming -- Same as "minimum access programming", which see.

minimum latency routine -- Same as "minimum access routine" , which see.

minor cycle -- Digital Computers. In a digital computer using serial transmission , the time required for the transmission of one machine word, including the space between words.

mistake -- Computers. A human error which results in an incorrect instruction in a program or in coding, an incorrect element of information, or an incorrect manual operation.

modifier -- Digital Computer Programming. A quantity, sometimes the cycle index, used to alter the address of an operand.

modify -- Digital Computer Programming. 1. To alter in an instruction the address of the operand. 2. To alter a subroutine according to a defined parameter.

modulo n check -- Computers. A form of check digits, such that the number of ones in each number A operated with is compared with a check number B carried along with A equal to the remainder of A when divided by n. For example, in a "modulo 4 check", the check numbers will be 0, 1, 2, or 3, and the remainder of A when divided by 4 must equal the reported check number B, or else an error has occurred.

N: non-erasable storage -- Storage media which cannot be erased and reused, such as punched paper tapes and punched cards.

non-volatile storage -- Storage media which retain information in the absence of power, such as magnetic tapes, drums, or cores.

notation -- Arithmetic. A manner of representing numbers. If quantities are written in the scale of notation n, then the successive positions of the digits report the powers of n. Thus 378 in the scale of 10 or decimal notation, means 3 hundreds, 7 tens, and 8. 1101 in the scale of 2, or binary notation, means 1 eight, 1 four, no twos, and 1 one. 764 in the scale of 8, or octal notation, means 7 sixty fours, plus 6 eights, plus 4.

numeric coding -- A system of coding or abbreviation in the preparation of machine language such that all information is reported in numbers. For example, ten places such as Boston, New York, Philadelphia, Washington, etc., may be reported as decimal digits 0, 1, 2, 3 ...., whereas in "alphabetic coding" alphabetic abbreviations BO, NY, PH, WA, ... would be acceptable to the machine.

O: octal digit -- One of the sumbols 0, 1, 2, 3, 4, 5, 6, 7 when used as a digit in numbering in the scale of eight.

octal notation -- Notation of numbers in the scale of eight. For example, the number 217 in this scale means 2 times 8 squared (2 x 64 = 128), plus 1 times 8, plus 7, which equals 143 in decimal notation. The number 217 in octal is equal to 010, 001, 111 in binary, each octal digit being changed directly into its binary equivalent. The octal notation is rather convenient in dealing with binary machines because octal numbers are easier for human beings to read than binary numbers, and yet the conversion is immediate.

odd-even check -- Use of a digit carried along as a check which is 1 if the total number of ones in the machine word is even, and which is 0 if the total number of ones in the machine word is odd, or vice versa.

one-address (adjective) -- Digital Computer Programming. Having the property that each complete instruction includes an operation and specifies the location of only one register in the memory. Also called "single-address".

on-line data reduction -- Reduction of data that is just as fast as the data flows into the reduction process.

open subroutine -- Digital Computer Programming. A subroutine inserted directly into a linear sequence of instructions, not entered by a jump. Such a subroutine must be recopied at each point that it is needed in a routine.

operand -- Computers. Any one of the quantities entering into or arising from an operation. An operand may be an argument, a result, a parameter, or an indication of the location of the next instruction.

operating ratio -- Computer Operation. The ratio obtained by dividing (1) the total number of hours of correct machine operation (including time when the program is incorrect through human mistakes) by (2) the total number of hours of scheduled computer operation including preventive maintenance. For example, if the computer is scheduled for three shifts totaling 120 hours in a week, and if "preventive maintenance" takes 12 hours, and "unscheduled down-time" amounts to 3 hours, then the "operating ratio" is 87½%.

operation code -- Digital Computer Programming. That part of an instruction which designates the operation of arithmetic, logic, or transfer to be performed.

operation number -- Digital Computer Programming. A number indicating the position of an operation or its equivalent subroutine in the sequence forming a program. When a problem is stated in pseudo-code, each step must sometimes be assigned an operation number.

operator -- Computers. The person who actually operates the computer, puts problems on, presses the start button, etc.

optimum programming -- Programming which is the best from some point of view. See "minimum access programming".

"or" circuit -- Circuits. A circuit which has two input lines and one output line, and which has the property that whenever a pulse is present on one or both of the input lines, a pulse is provided on the output line.

order -- 1. Sequence. 2. Instruction. -- Because of this possible confusion, the word "order" with the meaning "instruction" is avoided by many computer people.

output -- Computers. 1. Information transferred from the internal storage of a computer to

secondary or external storage. 2. Information transferred to any device outside of the computer.

output block — Digital Computers. A segment of the internal storage reserved for receiving data to be transferred out.

output equipment — Computers. The equipment used for transferring information out of a computer.

output unit — Computers. The unit which delivers information outside the computer in acceptable language.

overflow — Computers. In a counter or register, the production of a number which is beyond the capacity of the counter. For example, adding two numbers, each within the capacity of the registers holding them, may result in a sum beyond the capacity of the register that is to hold the sum: overflow.

P: pack — Digital Computer Programming. To combine several different brief fields of information into one machine word. For example, the fields of an employee's pay number, weekly pay rate, and tax exemptions may be stored together in one word, each of these fields being assigned a different set of digit columns.

parallel operation — Computers. The flow of information through the computer or any part of it using two or more lines or channels simultaneously.

parallel storage — Computers. Storage in which all bits, or characters, or words are essentially equally available in space, without time being one of the coordinates. Parallel storage contrasts with serial storage. When words are in parallel, the storage is said to be parallel by words; when characters within words are dealt with simultaneously, not one after the other, the storage is parallel by characters.

parameter — Digital Computer Programming. In a subroutine, a quantity which may be given different values when the subroutine is used in different parts of one main routine, but which usually remains unchanged throughout any one such use. To use a subroutine successfully in many different programs requires that the subroutine be adaptable by changing its parameters.

parity check — Use of a digit (called the "parity digit") carried along as a check which is 1 if the total number of ones in the machine word is odd, and 0 if the total number of ones in the machine word is even. See "odd-even check".

patch — Digital Computer Programming. A section of coding inserted into a routine (usually by explicitly transferring control from the routine to the patch and back again) to correct a mistake or alter the routine.

permanent memory — Computers. Storage of information which remains intact when the power is turned off; for example, storage on a magnetic drum.

plotting board — Computers. An output unit which plots the curves of one or more variables as a function of one or more other variables.

plugboard — Punch Card Machines. A removable board holding many hundreds of electric terminals into which short connecting wire cords may be plugged in patterns varying for different programs for the machine. To change the program, one wired-up plugboard is removed and another wired-up plugboard is inserted. A plugboard is equivalent to a program tape which presents all instructions to the machine at one time. It relies on X-punches and other signals in the punch cards passing through the machine to cause different selections of instructions in different cases.

plug-in-unit — A subassembly of tubes, resistors, condensers, diodes, etc., wired together, which is of a standard type and which as a whole can be plugged in or pulled out easily.

point — Arithmetic. In a scale of notation, the position designated with a dot that marks the separation between the integral and fractional parts of the number. Called "decimal point" in the scale of 10 and "binary point" in the scale of 2.

post mortem (noun) — Digital Computer Programming. A diagnostic routine which either automatically or when called for, prints out information concerning the contents of all or a specified part of the registers of the computer, after a problem tape has "died" on the computer. The purpose of a post mortem tape is to assist in the location of an error in coding the problem or in machine function.

precision — Computation. The degree of exactness with which a quantity is stated, as contrasted with "accuracy", which is the degree of exactness with which a quantity is known or observed. The number of significant figures measures the precision of a number. For example, in "computer power required is 55.7843 kilowatts", the number is precise to six figures, but its accuracy certainly is much less.

prestore — Digital Computer Programming. 1. To set an initial value for the address of an operand or a cycle index. 2. To store a quantity in an available or convenient location before it is required in a routine.

printer — Computers. An output mechanism which prints or typewrites characters.

program (noun) — Computers. 1. A precise sequence of coded instructions for a digital computer to solve a problem. Note: For this meaning, the term "routine" is preferred by some people. 2. A plan for the solution of a problem. A complete program includes plans for the transcription of data, coding for the computer, and plans for the effective use of the results.

program (verb) — To make a program.

program parameter — Digital Computer Programming. A parameter incorporated into a subroutine during computation. A program parameter frequently comprises a word stored relative to either the subroutine or the entry point and dealt with by the subroutine during each reference. It may be altered by the routine. It may vary depending on point of entry.

program register — Digital Computers. The register in the control unit of the computer which stores the current instruction of the program and thereby completely controls the operation of the computer during the cycle of execution of that instruction. Same as "control register". Also called "program counter".

programmed checking — Computers. A system of checking whereby (1) before running any problem P a sample problem of the same type with known answer is run, and (2) mathematical or logical checks of operations, such as comparing

A x B with B x A, are included in the program for P, and (3) reliance is placed on a very high probability of correctness rather than built-in error-detection circuits.

programmer -- A person who prepares sequences of instructions for a computer, without necessarily converting them into the detailed codes.

program-sensitive error -- Computers. An error arising from unforeseen behavior of some circuits, discovered when a comparatively unusual combination of program steps occurs.

program step -- Computers. A step in a program, usually one instruction.

program tape -- Computers. The tape which contains the sequence of instructions to the computer for solving a problem.

pseudo-code -- Digital Computer Programming. An arbitrary code, independent of the hardware of a computer, which must be translated into computer code if it is to direct the computer.

pseudo-random (adjective) -- Computation. Having the property of being produced by a definite calculation process, but at the same time satisfying one or more of the standard tests for statistical randomness.

pulse -- Circuits. In general, a sharp difference between the normal level of some medium corresponding to the average height of a wave and a high or low level of that medium corresponding to the crest or trough of a narrow wave; often, a sharp voltage change.

pulse code -- A set of pulses to which a particular meaning has been assigned; the binary representations of a character.

punch card -- Computers. A card of constant size and shape, suitable for punching in a pattern that has meaning, and for being handled mechanically. The punched holes are usually sensed electrically by wire brushes or mechanically by metal fingers.

punch card machinery -- Machinery which operates with punch cards.

punched tape -- Paper tape punched in a pattern of holes so as to convey information.

punch position -- In the case of 80-column punch cards, the position of a punch in a row on the card, denoting a decimal digit 0 to 9, or what are called an "X punch" (row 11), or a "Y punch" (row 12).

<u>Q</u>: quantity -- A positive or negative real number in the mathematical sense. Note: The term "quantity" is preferred by some computer people for referring to numeric data; the term "number" is preferred in the sense of integer or natural number, as in "the number of digits".

<u>R</u>: random access -- Computers. Access to the memory or storage under conditions where the next register from which information is to be obtained is chosen at random. For example, access to names in the telephone book is "random access"; the next name that anyone is going to look up in the book may be almost anywhere in the book with roughly equal probability.

random access programming -- Programming a problem for a computer without regard to the time for access to the information in the registers called for in the program. Contrasted with "minimum access programming".

random number -- A number formed by a set of digits selected from a random sequence of digits. A sequence of digits is random when it is constructed by a process under which each successive digit is equally likely to be any of the n digits to the base n.

rapid memory -- Computers. The section of the whole memory from which information may be obtained the most rapidly.

read -- Computers. 1. To copy, usually from one form of storage to another, particularly from external or secondary storage to internal storage. 2. To sense the meaning recorded in arrangements of hardware.

read-around-ratio -- Digital Computers. In cathode-ray-tube storage, the number of times that information can be recorded successively as an electrostatic charge on a single spot in the array, before the charge on surrounding spots in the array must be restored if not to be lost. This number is referred to also as the "read-around".

real time -- In solving a problem, a speed sufficient to give an answer in the actual time during which the problem must be solved. For example, in the case of a human being driving a motor car: at 30 miles an hour he can regularly solve nearly all his problems in real time; and at 100 miles an hour he will regularly fail to solve some of his problems in real time.

real time operation -- Computer Operation. Solving problems in real time. More precisely, processing data in time with a physical process so that the results of the data-processing are useful in guiding the physical operation.

red-tape operations -- Digital Computer Programming. Computer operations called for by a program which do not directly contribute to solving the problem; namely, arithmetical, logical, and transfer operations used in modifying the address section of other instructions, in counting cycles, in rearranging data, etc.

redundant check -- Computers. A check which uses extra digits in machine words, but not complete duplication, to help detect malfunctions and mistakes.

reel -- A spool of tape, generally magnetic tape.

reference record -- Digital Computer Programming. An output of a compiler that lists the operations and their position in the final specific routine, and contains information describing the segmentation and storage allocation of the routine.

regenerate -- Digital Computers. In the operation of electrostatic storage, to restore information currently held in a cell on the cathode ray tube screen in order to counteract fading and disturbances.

register -- Computers. The hardware for storing one machine word.

relative address -- Digital Computer Programming. A label used to identify the position of a memory location in a routine or subroutine. Relative addresses are translated into absolute addresses by adding some specific "reference" address, usually the address at which the first word of the routine is stored. For

example, if a relative address instruction specifies an address n and the address of the first word of the routine is k, then the absolute address of the memory location is n+k.

relative coding — Digital Computer Programming. Coding in which all addresses refer to an arbitrarily selected position, or in which all addresses are represented symbolically.

repetition rate -- Computers. The fastest rate of electronic pulses usually used in the circuits of the machine.

reproducer -- Punch Card Machines. A punch card machine that punches cards to agree as may be specified with other cards.

rerun -- Digital Computer Programming. To run a a program or a portion of it over again on the computer.

return point -- Digital Computer Programming. One of a set of planned-for points in a program such that if an error is detected in between two such points, to rerun the problem it is only necessary to go back to the last rerun point, instead of returning to the start of the problem. Rerun points are often three to five minutes apart so that very little computer time is required for a rerun. All information pertinent to a rerun is available in standby registers during the whole time from one rerun point to the next.

rerun routine -- Digital Computer Programming. A routine designed to be used in the wake of a malfunction or a mistake to reconstitute a routine from the last previous rerun point.

reset -- To return a register to zero or to a specified initial condition.

resolver -- Analog Computers. A device for resolving a vector into two mutually perpendicular components.

rewind -- Computers. To return a magnetic tape to its beginning.

rollback — Digital Computer Programming. Same as "rerun", which see.

restore -- Computers. To return a cycle index, a variable address, or other computer word to its initial value. See also "reset".

round off -- Computation. To change a more precise quantity to a less precise one, usually choosing the nearest less precise one; see "precision".

rounding error -- Computation. The error resulting from dropping certain less significant digits of a quantity, and applying some adjustment to the more significant digits retained. Also called "round-off error". A common round-off rule is to take the quantity to the nearest digit. Thus pi, 3.14159265..., rounded to four decimals is 3.1416. Note: Alston S. Householder suggests the following terms: "initial errors", "generated errors", "propogated errors" and "residual errors". If x is the true value of the argument, and x^* the quantity used in computation, then, assuming one wishes $f(x)$, $x-x^*$ is the initial error; $f(x) - f(x^*)$ the propagated error. If f_a is the Taylor, or other, approximation utilized, then $f(x^*) - f_a(x^*)$ is the residual error. If f^* is the actual result then $f_a - f^*$ is the generated error, and this is what builds up as a result of rounding.

routine -- Digital Computers. 1. A sequence of operations which a digital computer may perform. 2. The sequence of instructions determining these operations. 3. A set of coded instructions arranged in proper sequence to direct the computer to perform a desired operation or series of operations. See also "subroutine" and "program".

roll out (verb) -- Computers. To read out of a register or counter by the following process: add to the digits in each column simultaneously; do this 10 times (for decimal numbers); when the result in each column changes from 9 to 0, issue a signal.

run (noun) -- Computers. 1. One performance of a program on a computer. 2. Performance of one routine, or several routines during which the human operator does not have to do anything.

S: scale (verb) -- Computation. To change the scale (that is, the units) in which a variable is expressed so as to bring it within the capacity of the machine or program at hand.

scale factor -- Computation. One or more factors used to multiply or divide quantities occurring in a problem and convert them into a desired range, such as the range from plus one to minus one.

screen — Circuits. In an electrostatic storage tube, the surface where electrostatic charges are stored. In a pentode, one of the grids.

secondary storage -- Computers. Storage that is not an integral part of the computer but directly linked to and controlled by the computer; for example, magnetic tapes.

segment (noun) — Digital Computer Programming. In a routine too long to fit into internal storage, a part short enough to be stored entirely in the internal storage yet containing the coding necessary to call in and jump automatically to other segments. Routines which exceed internal storage capacity may be automatically divided into segments by a compiler.

segment (verb) -- To make segments.

sense (verb) -- Computers. 1. To determine the arrangement of some element of hardware, especially a manually-set switch. 2. To read holes punched in paper.

sentinel -- Digital Computer Programming. A symbol marking the beginning or the end of some piece of information such as a field, item, block, tape, etc. a tag.

select — Logic. To take A if the report on a certain condition is yes, and take B if the report is no.

selector -- Punch Card Machines. A mechanism which reports a condition and causes a card or an operation to be selected accordingly.

sequence (verb) -- Logic. To select A if A is greater than or equal to B, and select B if A is less than B, or some variation of this operation.

sequence checking routine — A checking routine which checks on every instruction executed, printing certain data. It may be designed to print out the coded instruction with addresses, and the contents of each of several registers for each instruction as it is executed. Or it may be designed to print out only selected data, such as transfer instructions when they occur, and the quantity actually transferred. Many variations are possible. A good flexible sequence checking routine will provide for several variations in itself.

sequence-control tape -- Program tape. (obsolescent term).

sequential control -- Computers. The manner of control of a computer in which instructions to it are set up in a sequence and are fed in that sequence to the computer during the solution of a problem.

sequencer -- Punch Card Machines. A mechanism which will put items of information in sequence. It will determine if A is greater than, equal to, or less than B, and will accordingly route cards containing A and B into a pocket at different times.

serial -- Computers. Handled one after the other in a single piece of equipment.

serial operation -- Computers. The flow of information through the computer or in any part of it using only one line or channel at a time. Contrasted with "parallel operation."

serial storage -- Computers. Storage in which time is one of the coordinates used to locate any given bit, character, or (especially) word. Storage in which words, within given groups of several words, appear one after the other in time sequence, and in which access time therefore includes a variable latency or waiting time of zero to many word-times, is said to be serial by word. Storage in which the individual bits comprising a word appear in time sequence is serial by bit. Storage for coded decimal or other non-binary numbers in which the characters appear in time sequence is serial by character; for example, magnetic drums are usually serial by word but may be serial by bit, or parallel by bit, or serial by character and parallel by bit, etc.

serial transfer -- Computers. A system of data transfer in which the characters of an element of information are transferred in sequence over a single path in consecutive time positions.

service routine -- Digital Computer Programming. A routine designed to assist in the actual operation of the computer. Tape comparison, block location, certain post mortems, and correction routines fall in this class.

shift -- To move the characters of a unit of information columnwise right or left. In the case of a number, this is equivalent to multiplying or dividing by a power of the base of notation (usually ten or two). This is regularly performed as a special rapid operation, much faster than usual multiplication or division.

sign digit -- A one or a zero used to designate the algebraic sign of a quantity plus or minus.

significant digits -- If the digits of a number are ranked according to their significance, and the significance of a digit is greater when it occupies a column corresponding to a higher power of the base, then the significant digits of a number are a set of digits from consecutive columns beginning with the most significant digit different from zero and ending with the least digit whose value is known or assumed to be relevant.

simulation -- The representation of physical systems by computers, models, and associated equipment.

single-address -- Same as "one-address", which see.

skip (noun) -- An instruction to proceed to the next instruction; a "blank" instruction.

slow memory -- Computers. Sections of the memory from which information may be obtained automatically but not at the fastest rate of the several sections.

sonic delay line -- A delay line which uses pulses in the molecules of the medium, in contrast with an electrical delay line which uses electrical pulses in a wire or in an assembly of coils and capacitors.

sort -- To arrange items of information according to rules dependent upon a key or field contained by the items, such as previously chosen classes of items.

sorter -- Punch Card Machines. A machine which sorts cards according to the punches in a specified column of the card.

specific coding -- Digital Computer Programming. Coding in which all addresses refer to specific registers and locations.

specific routine -- Digital Computer Programming. A routine expressed in specific computer coding designed to solve a particular mathematical, logical, or data-handling problem.

standardize -- Computation. To adjust the exponent and coefficient of a floating-point result so that the coefficient lies in the prescribed normal range.

static storage -- Computers. Storage such that information is fixed in space and available at any time provided the power is on; for example, flop, electrostatic, or coincident-current magnetic-core storage.

static subroutine -- Digital Computer Programming. A subroutine which involves no parameters other than the addresses of the operands. This is a subroutine which requires only the relative addresses of the operands, their insertion, and its transformation from relative to specific coding.

storage -- Computers. 1. The unit which holds or retains items of information. 2. Any device into which information can be introduced, held, and then extracted at a later time. The mechanism or medium in which the information is stored need not form an integral part of a computer. Synonyms: memory, store (in English usage).

storage capacity -- Same as "memory capacity", which see.

storage operation -- One of the operations of reading, transferring, storing, or writing information.

storage register -- A register in the memory or storage of the computer, in contrast with a register in one of the other units of the computer.

storage tube -- Same as "electrostatic storage tube", which see.

store (noun) -- Same as "storage", which see.

store (verb) -- To transfer a piece of information to a device from which the information unaltered can be obtained at a later time.

subprogram -- A part of a program.

subroutine -- Computers. 1. A short or repeated sequence of instructions for a computer to solve a part of a problem; a part of a routine. 2. The sequence of instructions necessary to direct the computer to carry out a well-defined

mathematical or logical operation; a subunit of a routine. A subroutine is often written in relative or symbolic coding even when the routine to which it belongs is not.

summary punch -- Punch Card Machines. A punch card machine which may be attached by a many-wire cable to another machine (for example, a tabulator), and which will punch out on a card the information produced or calculated or summarized by the other machine.

summation check — Computer Operation. A redundant check in which groups of digits are summed, usually without regard for overflow, and that sum checked against a previously computed sum to verify accuracy of computation.

symbolic address — Digital Computer Programming. A label chosen to identify a particular word, function or other information in a routine, independent of the location of the information, within the routine. Also called "floating address".

symbolic logic -- Exact reasoning about nonnumerical relations using symbols that are efficient in calculation. A branch of this subject known as Boolean algebra has been of considerable assistance in the logical design of computing circuits. Also called "mathematical logic".

synchronous computer -- An automatic digital computer where the performance of all ordinary operations starts with equally spaced signals from a master clock.

T: tabulator -- Punch Card Machines. A punch card machine which takes in punch cards and instructions and produces lists, totals, and tabulations of the information on separate forms or on continuous paper.

tag — Digital Computer Programming. A unit of information, whose composition differs from that of other members of the set so that it can be used as a marker or label; a sentinel.

tank -- A unit of delay-line storage, usually of mercury and operating acoustically, containing a set of channels each forming a separate recirculation path.

tape -- Computers. Magnetic tape or punched paper tape, sometimes other kinds of tape.

tape feed -- A mechanism which will feed tape to be read or sensed by the machine.

temporary storage -- Computers. Internal storage locations reserved for intermediate and partial results.

test routine -- Digital Computer Programming. A routine designed to show that a computer is functioning properly.

three-address (adjective) -- Digital Computer Programming. Having the property that each complete instruction includes an operation and specifies the location of three registers.

torque amplifier -- Analog Computers. A device possessing input and output shafts and supplying work to rotate the output shaft in positional correspondence with the input shaft without imposing any significant torque on the input shaft.

track — Computers. In a magnetic drum or magnetic tape, a single path containing a set of pulses.

transcribe -- To copy, with or without translating, from one external storage medium to another.

transfer (verb) -- 1. To transfer data; to copy, exchange, read, record, store, transmit, transport, or write data. To transfer does not modify the information. 2. To transfer control of a computer.

transfer (noun) — An act of transferring.

transfer check — A check that an operation of transferring has been correctly carried out.

transfer instruction -- Digital Computer Programming. An instruction or signal which conditionally or unconditionally specifies the location of the next instruction and directs the computer to that instruction.

transform — Digital Computer Programming. To change information in structure or composition without significantly altering the meaning or value; to normalize, edit, or substitute.

translate — Computers. To change information from one language to another without significantly affecting the meaning.

trouble-location problem — A test problem whose incorrect solution supplies information on the location of faulty equipment; used after a check problem has shown that a fault exists.

trouble-shoot — To search for the cause for a coding mistake or a computer malfunction in order to remove it.

truncate — Computation. To drop digits of a number or terms of a series thus lessening precision. See "precision". For example, the number pi "3.14159265...." is "truncated" to three figures in "3.14".

truncation error -- Computation. The error resulting from the use of only a finite number of terms of an infinite series, or from the approximation of operations in the infinitesimal calculus by operations in the calculus of finite differences.

trunk — A path over which information is transferred; a bus.

twin check -- A continuous check of computer operations achieved by duplication of the hardware to perform them together with automatic comparison.

two-address (adjective) — Digital Computer Programming. Having the property that each complete instruction includes an operation and specifies the location of two registers, usually one containing an operand and the other the result of the operation.

U: unconditional transfer -- Digital Computer Programming. In a digital computer which ordinarily obtains its instructions serially from an ordered sequence, an instruction which causes the following instruction to be taken from an address which is not the next one in the sequence.

unwind — Digital Computer Programming. To code explicitly, at length and in full, all the operations of a cycle, in such a way as to eliminate all red-tape operations. Unwinding may be performed automatically by the computer during assembly, generation, or compilation.

unpack — Digital Computer Programming. To separate packed items of information each into a separate machine word. See "pack".

V: validity — Computation. Correctness, especially the degree of closeness by which an iterated approximation approaches the desired correct result.

variable cycle operation -- Computer Operation. Operation of a computer whereby any cycle of operation may be longer or shorter than the average. This is the kind of operation in an "asynchronous computer".

verifier -- 1. Punch Card Machines. A punch card machine operated manually which reports by signals whether punched holes have been inserted in the wrong places in a punch card or have not been inserted at all. 2. Computers. An auxiliary device on which a previous manual transcription of data can be verified by comparing a current manual transcription of it character-by-character during the current process.

verify -- 1. To check, usually with an automatic machine, one typing or recording of data against another in order to minimize the number of human errors in the data transcription. 2. In preparing information for a computer, to make certain that the information as prepared is correct.

volatile memory -- Computers. Memory or storage having the property that if the power is turned off, the information vanishes; delay line memory, electrostatic storage tubes.

volatile storage -- Same as "volatile memory".

W: Williams tube -- Digital Computers. A cathode-ray tube for electrostatic storage of information of the type designed by F.C. Williams of the University of Manchester, England.

word -- Digital Computers. An ordered set of characters which has at least one meaning, and is stored and transferred by the computer circuits as a unit. Also called "machine word". Ordinarily, a word has a fixed number of characters, and is treated by the control unit as an instruction, and by the arithmetic unit as a quantity. For example, a computer may regularly handle numbers or instructions in units of 36 binary digits.

word-time -- Digital Computers. Especially in reference to words stored serially, the time required to transfer a machine word from one storage device to another.

working storage -- Digital Computers. A portion of the internal storage reserved for data upon which operations are currently being performed, and for intermediate and partial results, like a work-sheet in pencil and paper calculation.

write -- Digital Computers. 1. To copy information usually from internal to external storage. 2. To transfer information to an output medium. 3. To record information in a register, location, or other storage device or medium.

Z: zero -- Digital Computers. The computer's conceptions of zero. Note: The computer may provide for two zeros. Positive binary zero is represented by the absence of digits or pulses in a word. Negative binary zero in a computer operating with ones' complements may be represented by a pulse in every pulse position in a word. In a coded decimal computer, decimal zero and binary zero may not have the same representation. In most computers, there exist distinct and valid representations both for positive and for negative zero.

zero-address instruction -- Digital Computers. An instruction specifying an operation in which the location of the operands are defined by the computer code, so that no address need be given explicitly.

zero-access storage -- Digital Computers. Storage for which the latency or waiting time is always negligible.

zero-suppression -- The elimination of non-significant zeros to the left of the integral part of a quantity before printing is begun. To suppress these zeros is one of the operations in editing.

zone -- 1. Punch Cards. Any of the three top positions 12, 11, and 0. In these zone positions a second punch can be inserted, so that with punches in the remaining positions 1 to 9, enough two-punch combinations are obtained to represent alphabetic characters. 2. Digital Computers. A portion of internal storage allocated for a particular purpose.

- END -

ROSTER OF ORGANIZATIONS IN THE FIELD OF COMPUTERS AND AUTOMATION

(Supplement, information as of November 3, 1954)

The purpose of this Roster is to report organizations (all that are known to us) making or developing computing machinery, or systems, or data-handling equipment, or equipment for automatic control and materials handling. In addition, some organizations making components may be included in some issues of the Roster. Each Roster entry when it becomes complete contains: name of the organization, its address and telephone number, nature of its interest in the field, kinds of activity it engages in, main products in the field, approximate number of employees, year established, and a few comments and current news items. When we do not have complete information, we put down what we have.

We seek to make this Roster as useful and informative as possible, and plan to keep it up to date in each issue. We shall be grateful for any more information, or additions or corrections that any reader is able to send us.

Although we have tried to make the Roster complete and accurate, we assume no liability for any statements expressed or implied.

This listing is a supplement to the cumulative Roster in the November, 1954 issue of "Computers and Automation", vol. 3, no. 9, and contains only additions or revisions as compared with that listing.

Abbreviations

The key to the abbreviations follows:

Size
- Ls Large size, over 500 employees
- Ms Medium size, 50 to 500 employees
- Ss Small size, under 50 employees (no. in parentheses is approx. no. of employees)

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Analog Computers and their Application to Heat Transfer and Fluid Flow – Part 2

(The Bibliography will be published in a forthcoming issue; Part 1 was published in the November, 1954, issue)

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A d-c electronic analog computer should include devices for multiplying a machine variable by a positive or negative coefficient, for generating the sum of two or more machine variables, for generating the product of two machine variables, for generating arbitrary functions of machine variables,[33] and for generating the time integral or the time derivative of a machine variable. The three basic elements which are interconnected to perform many of these functions are resistors, capacitors, and d-c amplifiers. The d-c amplifier is really the heart of this computer. Interconnections are made easily by means of patch cords and front panel jacks. Potentiometers can be used to set constant coefficients or can be wound to represent special functions. Multiplication or division can be effected by servomotor positioned potentiometers and trigonometric functions can be obtained by means of resolvers. The computer would also include regulated power supplies to furnish the voltages needed for the operation of the electronic components, means for recording or measuring the d-c voltage in the machine, and control circuits for starting the computation with the correct initial condition settings and for stopping the machine after the computation is completed.

D-C electronic analog computers have been used to solve linear differential equations with constant coefficients,[42] linear ordinary differential equations with variable coefficients,[33] nonlinear ordinary differential equations,[33] and sets of linearly independent simultaneous equations.[42] They have been used to study separately excited generators,[42] to study variable displacement hydraulic systems,[42] for trajectory calculations,[33] to solve aircraft flight equations,[33] and for the analysis and synthesis of servomechanisms.[33]

Special Purpose Computers

Because analog computers are reliable in operation, capable of continuous service over extended periods, and comparatively small and inexpensive, many have been constructed for special problems. One computer was constructed to determine the yield of radioactive isotopes produced by a pile or other source of radiation.[63] This computer could be used for any problems involving similar equations. Another was built to rapidly evaluate a in the equation cosh 2 a S/ cosh 2 a T = A, where S, T, and A were known.[87] Others have been constructed for the solution of phase equilibria in flash vaporization of mixtures of hydrocarbons,[96] for solving secular equations,[102] for the solution of partial differential equations,[86] for analyzing wave equation boundary value problems,[103] and for multicomponent fractionation calculations.[78]

Application of Analog Computers to Heat Transfer Problems

Analog computers of various types have been used to obtain solutions to the many problems concerned with the transfer of heat. Those problems specified by ordinary or partial differential equations or involving unsteady state heat transfer can be solved by means of general purpose electrical computers. The general purpose computer at the California Institute of Technology has been used to solve the ordinary differential equations concerned with the temperature rise in rotating electric machines during variable load cycles, to find the steady-state temperature distribution in a gas turbine rotor, and to solve various partial differential equations.[129] Electric circuit models for partial differential equations have been described by Kron.[84] The Heat and Mass Flow Analyzer (HMFA) at Columbia University is designed primarily for solving problems of unsteady-state heat conduction in solids with definite radiation and convection boundary resistances.[133] The HMFA is a continuation in this country by Victor Paschkis of work done in Europe on a method first devised by C. L. Beuken. It has been used to provide solutions to many problems -- including those involved in regenerator operation,[132] solidification of metals,[132] determination of economical insulation thickness,[109] the influence of through metal on heat loss from insulated walls,[135] and the setting up of charts and graphs on heat conduction problems.[115] Temperature patterns have been determined by geometrical analog methods.[119] This method consists of setting up an electrically conductive flat sheet to represent the heat transfer problem in question (current flow represents heat flow), applying the proper potentials to the edges of the sheet, and finding potential (temperature) patterns by means of a probe. Special electrical analog techniques have been used to analyze heat exchanger performance.[123] Special electrical analog computers have been constructed for particular thermodynamic calculations,[111] for analyzing a heating system,[137] and for studying the thermal behavior of houses.[127] Also, hydraulic[117] and air flow[110] analogy techniques have been used to

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(continued from page 24)

study heat transfer problems.

When a solid mass changes temperature as a result of the exchange of heat between itself and its surroundings, there are variable temperature gradients in the mass, a series of isothermal surfaces, a nonuniform changing field within it, related to the time rate of heat gained or lost by the mass, and a time to attain steady state. This is known as the unsteady state of heat transfer and may be associated with heat transfer through the mass into one face and out from another.[133]

Mathematical calculations of the effect of any imposed conditions on a given mass defined by shape, size, and the physical properties of its materials, have depended upon the solution of Fourier's differential equations for these conditions. Those cases that can thus be solved with acceptable simplicity are relatively few in number and exclude most of those of industrial importance. The difficulties imposed by the mathematical approach are partially overcome by graphical methods. These methods are based on the replacing of each differential equation by an equation of finite differences, a process sometimes called step integration. Graphical methods, however, are tedious and of limited application. Experimental solutions of industrial problems of unsteady state heat transfer, depending upon inserted thermocouples or other thermometric devices and upon some means of measuring the rate of heat transfer, are difficult, expensive, and often impossible under service conditions.

In addition to these mathematical, graphical, and experimental methods[133] of solving unsteady heat transfer problems, there is the electrical analogy method. The analogies between the flow of heat and the flow of electricity[130] and electrical models for the solution of heat problems[126] have long been known. Early models were based on a geometrical similarity between the body subjected to heat flow and the model body. The application of general purpose computers to heat transfer problems is based on the identity in form of the fundamental equations of heat flow and the flow of electricity. The electrical analog bears no geometrical similarity to the body being investigated. Thus, a single electrical general purpose computer can be used for a wide variety of heat transfer problems.

The general form for the differential equation for heat conduction in solids can be written as:[112]

$$\frac{\partial}{\partial x}k(x,y,z,T)\frac{\partial T}{\partial x}+\frac{\partial}{\partial y}k(x,y,z,T)\frac{\partial T}{\partial y}+\frac{\partial}{\partial z}k(x,y,z,T)\frac{\partial T}{\partial z}$$
$$+\,q(x,y,z,T,t)=c\,d\,(x,y,z,T)\frac{\partial T}{\partial t}\;\text{---------}\;(1)$$

where t = time.
T = temperature at x, y, z at time t.
q = rate of heat supply per unit volume.
k = thermal conductivity $= \frac{1}{R_t}$ = Btu/(hr) (sq.ft) (deg^F/ft).
d = density = mass per unit volume.
c = specific heat = heat capacity per unit mass = Btu/(lb) (deg^F).
$cd = C_t$ = Btu/^{o}F (cu.ft).

If $q = o$ and k, d, and c are constants, equation (1) takes the form

$$\frac{\partial T}{\partial t}=a\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}\right)\text{-----}(2)$$

where $a = \frac{k}{c\,d}$ = thermal diffusivity $= \frac{1}{R_tC_t} = \frac{\text{sq.ft}}{\text{hr}}$

The study of a thermal problem by the electrical analogy method involves the following steps:[134]

(1) Set up the analogous conditions by calculation. To calculate the circuit for a distributed irregular region or medium of any shape, consider that the region is composed of discrete parts or sections. The size and shape of these sections are governed by the configuration of the region, the boundary conditions, and the required accuracy of solution. Each section is represented by one lump in the electrical network. The electrical values for the lumps are calculated on the basis of the geometrical dimensions of the section represented; capacitance is proportional to volume and resistance is proportional to the ratio of the thickness per cross sectional area.[132] Radiation and convection surfaces for the region can be represented by boundary resistances.

(2) Build the R-C circuit to represent the heat transfer problem.

(3) Subject the circuit to the appropriate analogous initial and boundary conditions. Voltages would be applied to the circuit to represent temperatures and currents to represent flow. Transient or intermittent boundary conditions such as sudden applications of heat or changes in temperature can be reproduced. The resistances and capacitances can be adjusted to represent changes in k, c, d, or the surface boundary conditions.

(4) Measure the electrical quantities, such as voltage and current,[20] at the points at which the temperatures and heat flows are to be measured in the region or medium under investigation.

(5) Convert the results of the electrical investigation into heat units by calculation.

The fundamental similarity between the defining equations for the flow of heat within a rigid body and that of charge in an electric circuit are shown in Figure 2 on page 31. The solution of heat transfer problems by this electrical analogy method is based on two principles.[134] The first principle is the mathematical identity of the equations for heat flow and for certain electrical circuits and is exact. The second principle is the replacing of a circuit with evenly distributed properties by one with lumped properties and is approximate. Essentially this second step involves the replacing of each partial differential equation by an equation of finite differences.

To represent a one-dimensional heat-conduction problem by an electrical circuit the following procedure would apply.[133] Such a problem might arise in the case of heat flow across an infinite slab or through a rod insulated at the sides or in the case of a steam heated insulated pipe. Express the various quantities R_t, C_t, q, T, x_t, and t_t (defined in Figure 2 on page 31) for the thermal circuit in any desired consistent system of units. Choose a consistent system of units (not necessarily the same) for R_e, C_e, I, V, x_e, and t_e in the analogous electrical circuit. Then make $x_e = x_t$ and divide the thermal circuit into elements of dx_t length and the corresponding R_e, C_e cable into an equal number of elements of length dx_e. Give every element dx_e the same number of units of electrical resistance (R_e) and electrical capacitance (C_e), as the corresponding element dx_t has units of thermal resistance (R_t) and thermal capacitance (C_t). It is not necessary that the thermal path be of uniform cross section or that the elements dx_t be equal. Then by equations (3), (4), (5), and (6), or (7) and (8) of Figure 2, page 31, all the readings for V and I taken in the electrical circuit at the points defined by x_e and t_e will be numerically equal to values of T and q in the thermal circuit at points defined by x_t and t_t for $x_e = x_t$ and $t_e = t_t$.

Since R_e and C_e occur only as a product, the result will not be changed if R_e and C_e are changed individually. Refer to Figure 2, page 31. In equation (7), V can be replaced by nR_eC_e or $n(mR_e)C_e/m$, and t_e can be replaced by nt_e without altering the form of the solution. Since in equation (3) dV is replaced by k dV and R_e is replaced by nmR_e, I is therefore replaced by I(k/nm). Since in equation (5) dV is replaced by k dV and C_e is replaced by C_e/m, Q_e is therefore replaced by $Q_e(k/m)$. By suitably choosing k, m, and n, the electrical analog may be operated at convenient voltages and transient time intervals and may be built with feasible magnitudes of resistance and capacitance.[133]

The methods used for one-dimensional problems can also be applied to three-dimensional problems. Three-dimensional problems of course require a much greater number of resistors, capacitors, and other electrical equipment. Analogous circuits for three-dimensional elements [128] are shown in Figure 3, page 32. The connection of the resistances into a grid in accordance with the respective positions of each element and the connection of the bottom terminal of all capacitors to a common ground form the analogous circuit representing the entire body. The choice of coordinate systems depends upon the shape of the body and the boundary conditions. In many problems there is a certain degree of symmetry which can be advantageously used to reduce the number of components required in the network; e.g., in a cylindrical problem with axial symmetry it is necessary to use only a two-dimensional network in the z and r coordinates. Coefficients of surface heat transfer can be represented by resistances and transient boundary conditions can be approximated.

Any problem in physics or engineering which can be specified by partial differential equations, such as occur in heat flow, fluid flow, or stress problems, can be approximated by electrical networks. By extending the methods described above networks can be constructed for many more complex equations, such as those for transient heat flow.[129]

The possibility of changing the time scale is of paramount importance for the practicability of the method. The time ratio $TR = t_e/t_t = aC_eR_e$ where t_e is the time in the electrical circuit, t_t is the time in the thermal circuit, a is the thermal diffusivity, C_e is the electrical capacitance, and R_e is the electrical resistance. With a low TR, a heat process whose actual time may be hours or days could take a few minutes in the analog. With a high TR, a heat process whose actual time is fractions of a second could take several minutes in the analog. By changing the time scale, times are achieved which permit a practical experimental run and allow easy reading of the instruments.[133]

From the standpoint of time, electrical analog heat flow computers may be divided into three groups: long-time computers whose runs last from several minutes to several hours, intermediate-time computers whose runs last from fractions of a second to several seconds, and short-time computers whose runs last fractions of a second. The RC time constant for these computers has to be considered from various aspects: namely, cost of equipment, leakage, instrumentation, and manipulation. Because of the infinite variety of the possible designs for each type it is difficult to compare costs. As far as leakage goes, the short-and intermediate-time computers permit the use of small, extremely high quality capacitors and require low resistances which result in favorable use-

ful to leakage resistance ratios. In short- or intermediate-time computers oscilloscopes or oscillographs are needed and the resultant accuracy is 2 - 5%. Long-time computers can use multiple point or slower recording instruments or instruments which print every two seconds. The attainable accuracy is 1/3 to 1/5%. When varying boundary conditions are specified, the short- and intermediate-time computers require special input circuits for each different boundary condition but the long-time computers can make use of continuous or stepwise manual control. For voltage dependent parameters (such as arise from the temperature dependence of thermal conductivity or specific heat) short- and intermediate-time computers require electronic circuits or cam drive equipment. In long-time computers the changes can be effected in steps from observation of instrument readings by manual switching or automatic relay operation. Some problems involve physical happenings such as two materials in and out of thermal contact. If alternation is at regular intervals depending on time only, no difficulties are encountered in the short-time apparatus. However, if the intervals are irregular or depend upon observations during the run of the test, only long-time computers are feasible. In conclusion, it may be said that the short-time computer is well suited for more qualitative analysis of problems with constant paramenters. The intermediate-time computer's field of greatest significance is in problems with simple operating conditions and constant parameters. The long-time computer is the most versatile apparatus and, so far, is indispensable for complex problems and for nonlinear parameters.[132]

The limitations of these methods are instrument errors, inaccuracies due to leakage and stray currents, inaccuracies due to lumping, and the need to know such physical constants as specific heat, density, thermal conductivity, and film conductance. However, this last is not too serious a problem because these properties are often known within limits (to 10% anyway). Besides, it is possible to determine these properties experimentally or operate the analog in reverse to establish the properties.[131] To counteract the inaccuracies due to leakage, use a small number of lumps. To counteract the inaccuracies due to lumping, use a large number of lumps. Therefore, it can be seen that for a given problem a practical compromise must be achieved. If the number of lumps is constant during a test run, the error is independent of the length of the run. The selection of nonuniform cross sections or lumps does not appear to influence accuracy. Therefore, the lumps can be chosen to give a greater number of readings in that part of the body to be investigated which is of greater interest.[134]

Application of Analog Computers to Fluid Flow Problems

Analog computers of various types have been used to obtain solutions to many problems concerned with the flow of fluids. The Westinghouse Mechanical Transients Analyzer was used to determine flow and pressure conditions in a penstock as a function of flow at the gate.[147] The general-purpose computer at the California Institute of Technology was used to solve various partial differential equations concerned with fluid flow.[129] Even before 1943 an electrical device was used for the analysis of the complex problems of reservoir and well behavior.[140]

Electrical analogy techniques have been advantageously employed in the analysis of many diverse hydraulic systems.[150] An equivalent circuit for any hydraulic system may be readily derived from two-terminal network analogies for each hydraulic component. A table of such analogies given in the cited reference is shown in Figure 4, page 33. The equations for system behavior may then be written and solved according to standard electric network analysis procedures. These methods can be most profitably applied in the field of automatic control, particularly servomechanisms.

Network calculators, such as the one at the Illinois Institute of Technology, have been used to solve the increasingly complex problems of calculating gas flows and pressure drops in gas distribution systems.[143] It is necessary to develop a relationship between analogous electrical and gas flow equations and then choose and adjust the electrical components to duplicate the gas distribution system. Also, an electrical network analyzer, comprised of special tungsten filament lamps whose nonlinear resistance characteristics closely approximate the fluid flow resistance of pipelines, has been constructed for solving the simultaneous head-loss equations for a pipeline network.[148]

Two-dimensional compressible fluid flow problems have been solved on adjustable resistance d-c calculating boards.[152] The convenient analogy employed is that between the equations of two-dimensional fluid flow and of conduction of electric currents in a plate for which the conductance is a function of the voltage gradient or of the current density. Since present day d-c boards are built for the analysis of short circuits in power systems, it is planned to build a new d-c board consisting of more units of higher accuracy which will be more suitable for field problems.

The Hydraulics Division of the Civil Engineering Department at the Massachusetts

(continued on page 42)

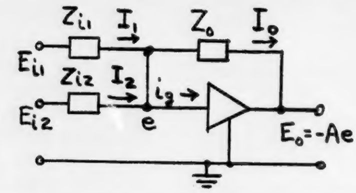
OPERATION | CIRCUIT | OUTPUT

1. General

$L\,di/dt + Ri + \frac{1}{C}\int_0^t i\,dt = e(t)$

$Ls\bar{i} + R\bar{i} + \frac{\bar{i}}{Cs} = \bar{e}$

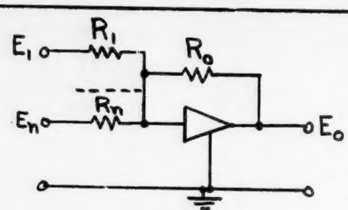
$\frac{\bar{e}(s)}{\bar{i}(s)} = \bar{Z}(s) = Ls + R + \frac{1}{Cs}$



Assume $A \to \infty$, $i_g = 0$

$E_o(s) = -\sum_{K=1}^{n} E_{iK}(s)\frac{Z_o(s)}{Z_i(s)}$

2. a) Addition
   b) Scale change on each input variable.
   c) Sign change on all input variables



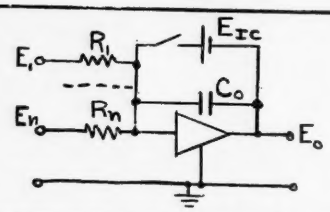
$E_o = -\left[\frac{R_o}{R_1}E_1 + \dots + \frac{R_o}{R_n}E_n\right]$

3. Integration

$E_o = -\frac{\int E_1/R_1\,dt}{C_o} - \dots - \frac{\int E_n/R_n\,dt}{C_o}$

or

$\frac{E_1}{R_1} + \dots + \frac{E_n}{R_n} = -C_o\frac{d}{dt}E_o$



$E_o = -\frac{1}{sC_o}\left[\frac{E_1}{R_1} + \dots + \frac{E_n}{R_n}\right] - E_{IC}$

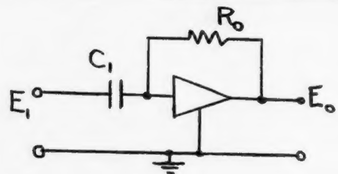
E_{IC} = Initial Condition

4. Differentiation

$E_1 = -\frac{\int E_o/R_o\,dt}{C_1}$

or

$C_1\frac{d}{dt}E_1 = E_o/R_o$



$E_o = sR_oC_1E_1$

5. $\frac{d^2y}{dt^2} + A\frac{dy}{dt} + By = f(t)$

$y = E_o \qquad f(t) = E_1$

$s^2Y = F(s) - AsY - BY$

$A = \frac{1}{R_1C_1} \qquad \frac{R_4}{R_3} = 1 \qquad B = \frac{A}{R_2C_2}$

$\frac{R_6}{R_5} = 1/B \qquad \frac{R_8}{R_7} = 1$

$\frac{R_{12}}{R_9} = \frac{R_{12}}{R_{10}} = \frac{R_{12}}{R_{11}} = 1$

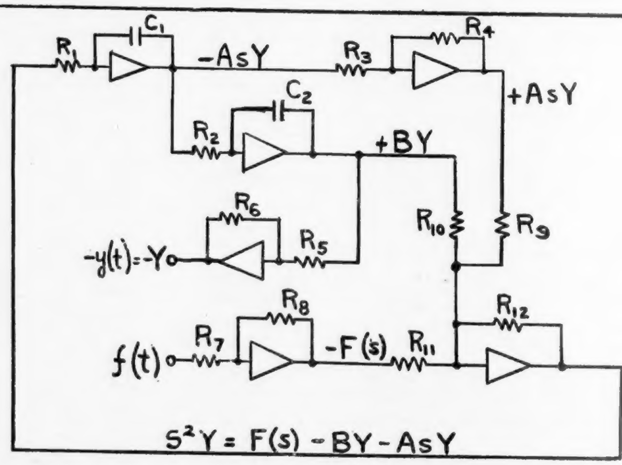


Figure 1 — Operational Amplifier Circuits

	ELECTRICAL	THERMAL
1. Conservation of scalar quantity	Charge (Coulombs)	Heat (Btu)
2. Scalar point function	Electric Potential (Volts)	Temperature (Degrees)
3.	Ohm's Law	Fourier's Law
4. Resistance concept	$R_e = dV/I$ (3) R_e = electrical resistance I = current through R_e dV = difference in potential across R_e	$R_t = dT/q$ (4) R_t = thermal resistance q = heat flow through R_t dT = difference in temperature across R_t
5. Capacity concept	$C_e = Q_e/dV$ (5) C_e = electrical capacity Q_e = charge stored in C_e dV = rise in electrical potential of C_e due to Q_e	$C_t = Q_t/dT$ (6) C_t = thermal capacity Q_t = heat stored in C_t dT = rise in temperature of C_t due to Q_t
6. One dimensional form of heat conduction equation for solids	$\frac{\partial V}{\partial t_e} = \frac{1}{R_e C_e} \frac{\partial^2 V}{\partial x_e^2}$ (7) t_e = time in electrical circuit x_e = distance along cable V = electrical potential at x_e at time t_e	$\frac{\partial T}{\partial t_t} = \frac{1}{R_t C_t} \frac{\partial^2 T}{\partial x_t^2}$ (8) t_t = time in thermal circuit x_t = distance along flow path T = temperature at x_t at time t_t
7. Flow	Amperes = Coulombs/sec	Btu/min
8. Capacity	Farads = Coulombs/volt	Btu/degF
9. Resistance	Ohms = Volts/Coulomb/Sec	degF/Btu/min
10. Heat flow across an infinite slab		A - surface of slab B - first layer of slab material C - second layer of slab material D - surface of slab

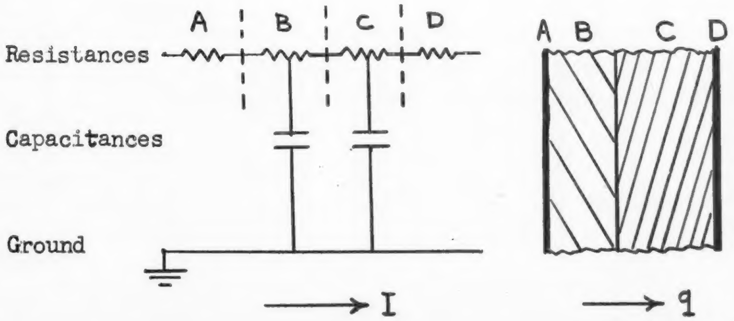
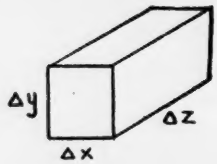


Figure 2 -- Comparison of Electrical and Thermal Relations



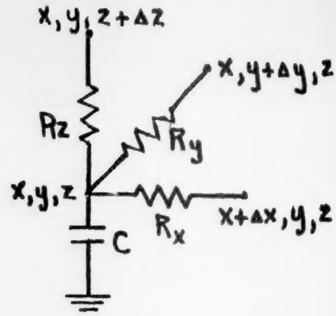
CARTESIAN COORDINATES

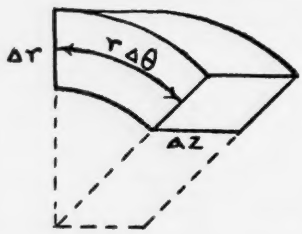
$$C = \Delta x\, \Delta y\, \Delta z\, c d$$

$$R_x = \frac{\Delta x}{\Delta y\, \Delta z\, k}$$

$$R_y = \frac{\Delta y}{\Delta x\, \Delta z\, k}$$

$$R_z = \frac{\Delta z}{\Delta x\, \Delta y\, k}$$





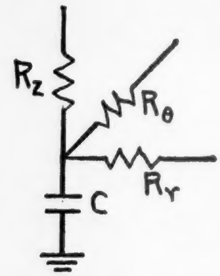
CYLINDRICAL COORDINATES

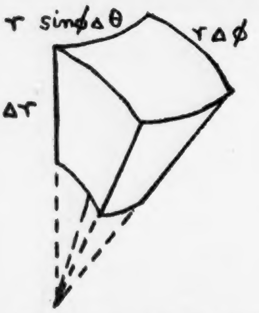
$$C = r\Delta\theta\, \Delta r\, \Delta z\, c d$$

$$R_r = \frac{\Delta r}{r\Delta\theta\, \Delta z\, k}$$

$$R_\theta = \frac{r\,\Delta\theta}{\Delta r\, \Delta z\, k}$$

$$R_z = \frac{\Delta z}{r\Delta\theta\, \Delta r\, k}$$





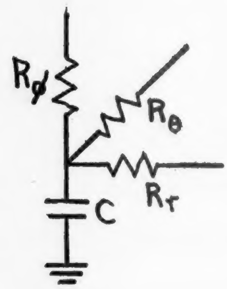
SPHERICAL COORDINATES

$$C = r^2 \sin\phi\, \Delta r\, \Delta\theta\, \Delta\phi\, c d$$

$$R_r = \frac{\Delta r}{r^2 \sin\phi\, \Delta\theta\, \Delta\phi\, k}$$

$$R_\theta = \frac{r \sin\phi\, \Delta\theta}{r\, \Delta r\, \Delta\phi\, k}$$

$$R_\phi = \frac{r\,\Delta\phi}{r \sin\phi\, \Delta r\, \Delta\theta\, k}$$



TRANSIENT HEAT FLOW EQUATION

$$\nabla^2 T = {}^1/_a\ {}^{\partial T}/_{\partial t} + f(t)$$

$1/a = cd/k$
$f(t)$ - arbitrary heat function applied to system
Required boundary conditions can be handled by suitable potentials.
c - Specific heat
d - Density
k - Thermal conductivity
T - Temperature

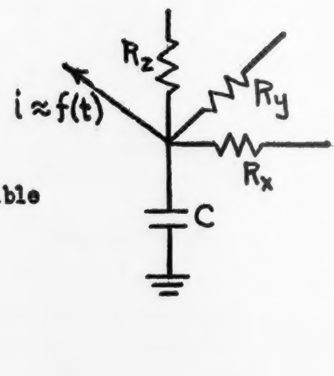


Figure 3 -- Analogous Electrical Circuits for Three-Dimensional Thermal Elements

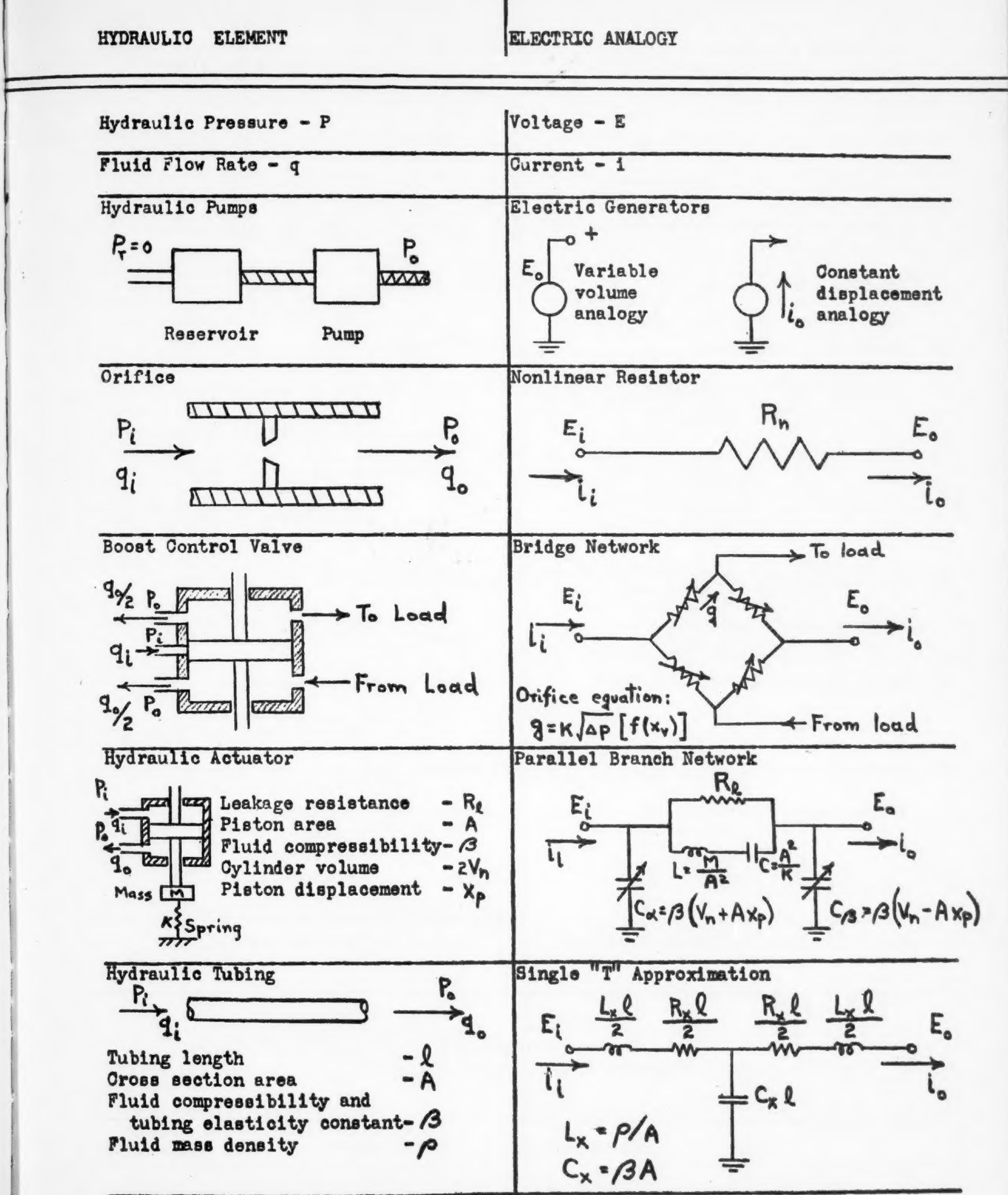
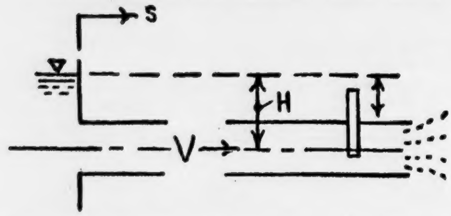
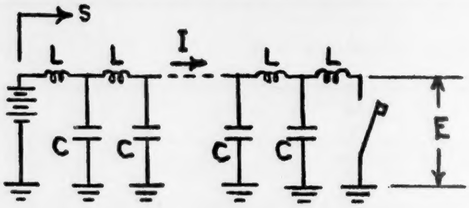


Figure 4 -- Electrical Analogies for Hydraulic Components

HYDRAULIC SYSTEM: Uniform frictionless pipe line	ELECTRICAL SYSTEM: Uniform lossless transmission line
	

1. Inertia equation: $-\frac{\partial V}{\partial s} = \frac{1}{g}\frac{\partial H}{\partial t}$ — Voltage drop: $-\frac{\partial E}{\partial s} = L\frac{\partial I}{\partial t}$

2. Continuity equation: $-\frac{\partial V}{\partial s} = \frac{w}{E_b}\left(1+\frac{E_b}{E_y}\frac{D}{e}\right)\frac{\partial H}{\partial t}$ — Line charging: $-\frac{\partial I}{\partial s} = C\frac{\partial E}{\partial t}$

3. Wave equations:
$$\begin{cases}\frac{\partial^2 H}{\partial t^2} = c^2\frac{\partial^2 H}{\partial s^2}\\ \frac{\partial^2 V}{\partial t^2} = c^2\frac{\partial^2 V}{\partial s^2}\end{cases}$$
Wave equations:
$$\begin{cases}\frac{\partial^2 E}{\partial t^2} = c^2\frac{\partial^2 E}{\partial s^2}\\ \frac{\partial^2 I}{\partial t^2} = c^2\frac{\partial^2 I}{\partial s^2}\end{cases}$$

4. Propagation velocity:
$$c = \sqrt{\frac{E_b/\rho}{1 + {}^{E_b}/_{E_y}\;{}^{D}/_{e}}}$$
Propagation velocity:
$$c = \sqrt{{}^{1}/_{LC}}$$

5. Surge impedance:
$$Z_o = {}^{c}/_{g}$$
Surge impedance:
$$Z_o = \sqrt{{}^{L}/_{C}}$$

6. Reflections:

   Open end: Pressure node: $\Delta H = 0$; Reflection factor: $r = -1$

   Closed end: Velocity: $\Delta V = 0$; Reflection factor: $r = +1$

   Reflections:

   Grounded end: Voltage node: $\Delta E = 0$; Reflection factor: $r = -1$

   Open end: Current node: $\Delta I = 0$; Reflection factor: $r = +1$

ANALOGY

Head H ⟷ Voltage E

Velocity V ⟷ Current I

Figure 5 -- Electrical-Hydraulic Analogy

PATENTS

Hans Schroeder
Milwaukee, Wisconsin

The following is a compilation of patents pertaining to computers and associated equipment from the Official Gazette of the United States Patent Office, dates of issue as indicated. Each entry consists of: patent number/ inventor(s) / assignee / invention.

September 21, 1954: 2,689,683 / P F M Gloess and G J R Piel, Paris, France / Société d'Electronique et d'Automatisme, Paris, France / Means for combining trains of number-representative pulses with various amplitudes.
2,689,684 / A Laternser, Horgan, Switzerland/ Landis A Gyr, A.G., Zug, Switzerland / Mechanical integrator for thermal quantities

September 28, 1954: 2,690,302 / G V Nolde, Berkeley, Calif / Marchant Calculators, Inc / Counter using a plurality of grid-controlled gas tubes
2,690,303 / G V Nolde and H K St. Clair, Berkeley, Calif / Marchant Calculators, Inc/ Decade counter using vacuum tubes
2,690,507 / W Woods-Hill, Letchworth, and D T Davis, Wandsworth Common, London, Eng / Intl Bus Machines Corp, N Y, N Y / Electronic multiplier
2,690,531 / K A Marggraf and W F Massman, Lemont, Ill / Ampatco Laboratories Corp, Lemont, Ill / Electromechanical integrator

October 5, 1954: 2,691,100 / N F Moody and W D Howell, Deep River, Ont, Canada / Natl Research Council, Ottawa, Ont, Can / Electronic binary counter
2,691,151 / P M G Toulon, New York, N Y / Products and Licensing Corp, N Y, and N Moore and W D Hall / Selective switching system
2,691,152 / R Stuart-Williams, Princeton, N J / Radio Corp of Amer / Switching system using an array of magnetic cores with binary numbers assigned to them
2,691,153 / J A Rajchman and R Stuart-Williams, Princeton, N.J / Radio Corp of Amer / Commutator switch using an array of magnetic cores
2,691,154 / J A Rajchman, Princeton, N J / Radio Corp of Amer / Magnetic information handling system using a plurality of magnetic cores with multiple windings on each
2,691,155 / M Rosenberg, Trenton, and R Stuart-Williams, Princeton, N J / Radio Corp of Amer / Matrix of magnetic cores for information storage
2,691,156 / J Saltz, Phila, Pa, and C S Warren, Collingswood, N J / Radio Corp of Amer / Magnetic memory reading system
2,691,157 / R Stuart-Williams, Pacific Palisades, and M Rosenberg, Santa Monica, Calif / Radio Corp of Amer / Magnetic memory switching system
2,691,727 / J J Blair, Nutley, N J / Intl Standard Elec Corp, New York, N Y / Impulse storing and distributing circuit using a cathode-ray type tube

October 19, 1954: 2,692,082 / O Cesareo, Washington Twp, Bergen County, and W B Strickler, East Orange, N J / Bell Telephone Labs, Inc, New York, N Y / Automatic calculator
2,692,365 / F R Milson, Boreham Wood, England / S Smith & Sons (England) Ltd, London, Eng., and Furzehill Labs, Ltd, Boreham Wood, England / Servo system incorporating electric motors and amplifier circuits

* ——— * ——— *

ROSTER OF ORGANIZATIONS
(continued from page 23)

When Established

- Le Long established organization (1922 or earlier)
- Me Organization established a "medium" time ago (1923 to 1941)
- Se Organization established a short time ago (1942 or later) (no. in parentheses is year of establishment)

Interest in Computers and Automation

- Dc Digital computing machinery
- Ac Analog computing machinery
- Ic Incidental interests in computing machinery
- Sc Servomechanisms
- Cc Automatic control machinery
- Mc Automatic materials handling machinery

Activities

- Ma Manufacturing activity
- Sa Selling activity
- Ra Research and development
- Ca Consulting
- Ga Government activity
- Pa Problem-solving
- Ba Buying activity
  (Used also in combinations, as in RMSa "research, manufacturing and selling activity")

*C This organization has kindly furnished us with information expressly for the purposes of the Roster and therefore our report is likely to be more complete and accurate than otherwise might be the case. (C for Checking)

ROSTER

Bendix Computer Division Bendix Aviation Corporation, 5630 Arbor Vitae St., Los Angeles 45, Calif. / ORegon 8-2128 / *C
Electronic information processing machines. Electronic computers; data processing equipment; automatic control systems; Decimal Digital Differential Analyzer Model D-12; general

(continued on page 43)

Economies in Design of Incomplete Selection Circuits

Arnold I. Dumey
Potter Instrument Co., Great Neck, N.Y.

The design of complete rectangular switching matrices and of incomplete triode matrices has been well covered. (See "Synthesis of Electronic Computing and Control Circuits", by the Staff of the Computation Laboratory, Harvard University Press, 1951, and references cited therein.) Herein set forth is a method of producing all of the most economical choices for location of diodes where it is desired to select $N<2^n$ outputs individually by means of n bipolar inputs. We employ the manipulations of Boolean algebra, using for convenience $\cdot$ = and, v = or. Note particularly the absorption law, a(avb) = a v ab = a

Consider the case of the three bipolar inputs, corresponding to $2^0 = a$, $2^1 = b$, $2^2 = c$ and a matrix where it is desired to select only the combinations 0, 1, 3, 6, and 7. In binary form:

Column c	Column b	Column a	Line
0	0	0	0
0	0	1	1
0	1	1	3
1	1	0	6
1	1	1	7

To insure that line 0 will not be picked up if the line 1 is energized, the matrix must contain a rectifier on the 0 line in column a. To prevent pickup of the 0 line if 3 is called for, there must be a rectifier in <u>either</u> column a or b on the 0 line. In other words, to shut out 0 if any other number is called for, we must have a rectifier at a <u>and</u> a or b <u>and</u> b or c <u>and</u> c or b or a. Symbolically, a(avb)(bvc)(cvbva), which reduces by absorption to a(bvc). Therefore column a and one of the other two must be rectified. For line 1 we need ab(avbvc)(bvc) = ab. In other words, line 1 needs rectifiers in columns a and b.

For line 3: (avb)b(avc)c = bc

For line 6: (bvc)(cvbva)(cva)a = a(bvc)

For line 7: (cvbva)(cvb)ca = ac

The complete network is given in Figure 1.

The Boolean expression to be reduced can be taken immediately from a symmetric table which is easy to produce for any n variables, although its size for any n+1 represents an increase by a factor of 4. Such a table for n=4 variables is given in Figure II, which clearly displays its method of construction and extension.

Using the table, in the example first given, the intersections of row 0 with columns 1, 3, 6, and 7 yield a(avb)(bvc)(avbvc). For row 3 against columns 0, 1, 6 and 7 we get (avb)b(avc)c.

Obviously, where there is more than one choice, for example, line 6 in the problem, the point to be picked for rectification can be selected on considerations of loading, symmetry, packaging, or at random.

- END -

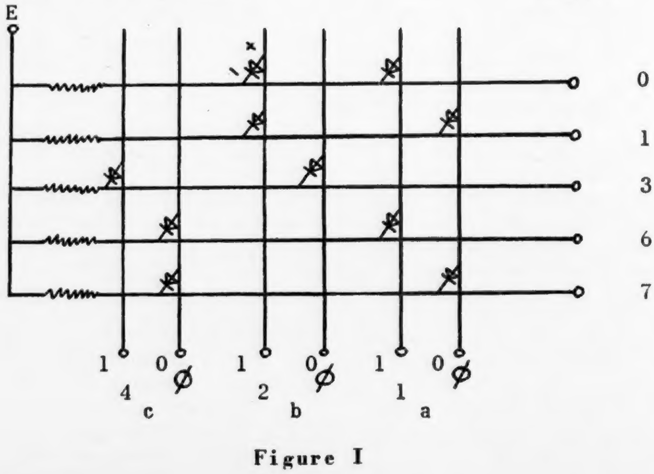


Figure I

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0		a	b	avb	c	avc	bvc	avbvc	d	avd	bvd	avbvd	cvd	avcvd	bvcvd	avbvcvd
1	a		avb	b	avc	c	avbvc	bvc	avd	d	avbvd	bvd	avcvd	cvd	avbvcvd	bvcvd
2	b	avb		a	bvc	avbvc	c	avc	bvd	avbvd	d	avd	bvcvd	avbvcvd	cvd	avcvd
3	avb	b	a		avbvc	bvc	avc	c	avbvd	bvd	avd	d	avbvcvd	bvcvd	avcvd	cvd
4	c	avc	bvc	avbvc		a	b	avb	cvd	avcvd	bvcvd	avbvcvd	d	avd	bvd	avbvd
5	avc	c	avbvc	bvc	a		avb	b	avcvd	cvd	avbvcvd	bvcvd	avd	d	avbvd	bvd
6	bvc	avbvc	c	avc	b	avb		a	bvcvd	avbvcvd	cvd	avcvd	bvd	avbvd	d	avd
7	avbvc	bvc	avc	c	avb	b	a		avbvcvd	bvcvd	avcvd	cvd	avbvd	bvd	avd	d
8	d	avd	bvd	avbvd	cvd	avcvd	bvcvd	avbvcvd		a	b	avb	c	avc	bvc	avbvc
9	avd	d	avbvd	bvd	avcvd	cvd	avbvcvd	bvcvd	a		avb	b	avc	c	avbvc	bvc
10	bvd	avbvd	d	avd	bvcvd	avbvcvd	cvd	avcvd	b	avb		a	bvc	avbvc	c	avc
11	avbvd	bvd	avd	d	avbvcvd	bvcvd	avcvd	cvd	avb	b	a		avbvc	bvc	avc	c
12	cvd	avcvd	bvcvd	avbvcvd	d	avd	bvd	avbvd	c	avc	bvc	avbvc		a	b	avb
13	avcvd	cvd	avbvcvd	bvcvd	avd	d	avbvd	bvd	avc	c	avbvc	bvc	a		avb	b
14	bvcvd	avbvcvd	cvd	avcvd	bvd	avbvd	d	avd	bvc	avbvc	c	avc	b	avb		a
15	avbvcvd	bvcvd	avcvd	cvd	avbvd	bvd	avd	d	avbvc	bvc	avc	c	avb	b	a	

Figure II

PUBLICATIONS

P25: NUMBLES—NUMBER PUZZLES FOR NIMBLE MINDS. Report. Contains collection of puzzles like:

```
      T R Y
 +T H E S E
 =T W V A S

    H A V E
 +    F U N
 =  W A S E

and   T R A I N   your
     +  W I T S
     =E N T N S
          WYE = VIF
```

In fact, you can also:
90893 85202 44393 29081

(Solve for the digits -- each letter stands for just one digit 0 to 9)

All are new numbles, additions, multiplications, etc.; some easy, some hard. Each with two messages, one open, one hidden. Hints for solution. Good exercises in logical reasoning...............$1.00

P14: CIRCUIT ALGEBRA—INTRODUCTION. Report. Explains simply a new algebra (Boolean algebra modified to include time) that applies to on-off circuits, using relays, electronic tubes, rectifiers, gates, flip-flops, delay lines, etc. Covers both static and sequential circuits. Applications to control, programming, and computing. Problems and solutions involving circuits.................$1.90

P16: SYMBOLIC LOGIC—TWENTY PROBLEMS AND SOLUTIONS. Report. Contains some problems by Lewis Carroll and John Venn (out of print), and many other new problems. Guide to using symbolic logic in actual situations.........................$1.80

Your money is returned at once if you are not satisfied. You can see these for almost nothing — why not take a look at them? Send request direct — not through a dealer. (P.S. We also offer 19 more publications, and 26 courses by mail. We have students in 47 states and territories, 20 foreign countries. Ask us for information.)

------MAIL THIS COUPON------

Edmund C. Berkeley and Associates,
815 Washington St., R108 Newtonville 60, Mass.

1. Please send me publications circled:
P14 P16 P25
Returnable in 7 days for full refund if not satisfactory. I enclose $............ in full payment (add 10¢ per item to cover cost of handling and mailing.)

2. Please send free announcement of ☐ publications and ☐ courses.

My name and address are attached.

INDEX

This index covers information published in the ten issues of COMPUTERS AND AUTOMATION, vol. 2, no. 9, December, 1953 to vol. 3, no. 9, November, 1954. In order not to delay the current issue, December, 1954, it has not been included in this index. The last part of each entry in the index gives: volume / number (month of issue), page number.

- END -

ANALOG COMPUTERS
(continued from page 29)

Institute of Technology is studying the application of analog computers to hydraulic engineering problems so that predictions can be made faster and more accurately.[153] Such problems would include river and reservoir behavior, surge tank behavior, and the many complex problems that arise in connection with the performance of hydroelectric plants. The application of analog computers to penstock, surge tank, and water hammer studies has been described.[151] This reference also sets up an electrical-hydraulic analogy in which the water hammer waves and surges of the hydraulic engineer become the traveling waves, electrical surges, and switching transients of the electrical engineer as shown in Figure 5, page 34.

Late in 1948, the Weather Bureau, U. S. Department of Commerce, developed an electronic device for stream flow routing that has proved to be highly effective in the preparation of river stage forecasts.[145] It was originally designed for routing flows from point to point along a stream, but subsequent studies indicated that the equipment is equally applicable to the direct routing of effective rainfall (runoff) over relatively large basins.

- END -

ROSTER OF ORGANIZATIONS
(continued from page 35)

purpose digital computers Model GG-15A and G-15D. Ms (150) Se (1952, division; 1929, corporation) DACc RMSPa

Canning, Sisson, & Associates, 914 So. Robertson Blvd., Los Angeles, Calif.
Consultants in applications of automatic data handling systems, electronic production control systems, etc. Ss Se (1954) DACc RCPa

Digital Control Systems, P. O. Box 779, La Jolla, Calif.
All employees have been transferred and certain assets have been sold to Litton Industries, Beverly Hills, Calif.

ElectroData Corporation (Consolidated Engineering Corporation affiliate), 717 N. Lake Ave., Pasadena 6, Calif. / SYcamore 8-6761 / *C
Electronic digital computers and computer components; input-output devices; magnetic tape units; punched card conversion equipment. Ms (200) Se (1950; parent company 1937) Dc RMSCPa

Electronic Engineering Co., 180 South Alvarado St., Los Angeles 57, Calif. / DUnkirk 2-7353 /
Design, development, and fabrication of specialized electronic equipment. Analog computing machinery. Analog-to-digital-to-analog converters. Polar-to-rectangular-to-polar converters. Servomechanisms. Ms (180) Se (1947) DAc RMSa

Magnetics Inc., Butler, Pa. / BUtler 71-745 /
Magnetic core materials for construction of computer memories. Ic RMSa

Minnesota Electronics Corp., 1058 University Ave., St. Paul 4, Minn. / CApital 6-8891 / *C
Digital and analog computers. Magnetic components, magnetic decision elements. Data reduction systems, telemetering. Ss (35) Se (1946) DAIc RMSa

J. B. Rea Co., 1723 Cloverfield Blvd., Santa Monica, Calif. / Exbrook 3-7201 / *C
Automatic control systems, general and special purpose digital computers, flight control systems for helicopters, automatic cruise control for aircraft, torpedo tracking systems, automatic data handling systems, aerodynamic systems analysis, simulation, nonlinear servo systems. Magnetic drums, magnetic heads, analog-to-digital converters, etc. Analog and digital computing facility. Ms (60) Se (1951) DASCc RMSCa

- END -

MONROBOT ELECTRONIC CALCULATOR

The MONROBOT is a general purpose digital computer, compact, ruggedized, reliable and reasonably priced. In the MONROBOT, decimal numbers are used. Since twenty digits are available, with a centrally located decimal point, there is no need for scaling or setting of decimal point. Neither overflow nor translation techniques are necessary. Orders are written for the calculator in virtually their original algebraic form.

Neither highly trained personnel nor extensive training effort are needed for the MONROBOT. Keyboard and automatic tape operations are counterparts of the simple programming procedures. Average office personnel become familiar with MONROBOT operation the first day. It prints out results on 8-1/2" wide paper roll, or perforates a paper tape as desired.

MONROBOT V is complete in one desk-size unit, ready to plug in and perform. MONROBOTS can be supplied with capacities to suit special requirements, avoiding excess investment for unnecessary facilities.

MONROBOT CORPORATION

MORRIS PLAINS NEW JERSEY

A SUBSIDIARY OF MONROE CALCULATING MACHINE COMPANY

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Hungarian Prelude to Automation -- Gene J. Hegedus
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Mechanical Translation -- Andrew D. Booth, Birkbeck College, London
Medical Diagnosis -- Marshall Stone, University of Chicago
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How to Talk About Computers — Rudolf Flesch, Author of "Art of Plain Talk"
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Digital Computer Questionnaire — Lawrence Wainwright
"How to Talk About Computers": Discussion -- G. G. Hawley and Others
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Introducing Computers to Beginners -- Geoffrey Ashe
Subroutines: Prefabricated Blocks for Building — Margaret H. Harper
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The Concept of Thinking — Elliot L. Gruenberg
General Purpose Robots -- Lawrence M. Clark
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Reciprocals -- A. D. Booth
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November: Computers in Great Britain — Stanley Gill
Analog Computers and their Application to Heat Transfer and Fluid Flow — Part I -- John E. Nolan
All-Transistor Computer -- Neil Macdonald

REFERENCE INFORMATION (in various issues):

Roster of Organizations in the Field of Computers and Automation / Roster of Automatic Computing Services / Roster of Magazines Related to Computers and Automation / List of Automatic Computers / Automatic Computing Machinery -- List of Types / Who's Who in the Field of Computers and Automation / Automation -- List of Outstanding Examples / Books and Other Publications / Glossary / Patents

Price of back copies, if available, $1.25 each.

A subscription (see rates on page 4) may be specified to begin with any issue from Nov., 1954 to date.

REPRINTS: Index No. 1 (from December, 1953, issue) — 20 cents

WRITE TO:

Edmund C. Berkeley and Associates
Publishers of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N. Y.

ADVERTISING IN "COMPUTERS AND AUTOMATION"

Memorandum from Edmund C. Berkeley and Associates
Publishers of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N.Y.

1. What is "COMPUTERS AND AUTOMATION"? It is a monthly magazine containing articles and reference information related to computing machinery, robots, automatic controllers, cybernetics, automation, etc. One important piece of reference information published is the "Roster of Organizations in the Field of Computers and Automation". The basic subscription rate is $4.50 a year in the United States. Single copies are $1.25. The magazine was published monthly except June and August between March, 1953, and September, 1954; prior to March 1953 it was called "The Computing Machinery Field" and published less often than ten times a year.

2. What is the circulation? The circulation includes 1200 subscribers (as of Nov. 23); over 300 purchasers of individual back copies; and an estimated 1500 nonsubscribing readers. The logical readers of COMPUTERS AND AUTOMATION are some 3500 or 4000 people concerned with the field of computers and automation. These include a great number of people who will make recommendations to their organizations about purchasing computing machinery, similar machinery, and components, and whose decisions may involve very substantial figures. The print order for the Dec. issue was 2100 copies. The overrun is largely held for eventual sale as back copies, and in the case of several issues the overrun has been exhausted through such sale. A mailing to some 2000 nonsubscribers in December, 1953 (with 173 responses up to March, 1954) indicated that two-thirds of them saw the magazine (library, circulation, or friend's copy) and of these two-thirds over 93% "liked it".

3. What type of advertising does COMPUTERS AND AUTOMATION take? The purpose of the magazine is to be factual and to the point. For this purpose the kind of advertising wanted is the kind that answers questions factually. We recommend for the audience that we reach, that advertising be factual, useful, interesting, understandable, and new from issue to issue.

4. What are the specifications and cost of advertising? COMPUTERS AND AUTOMATION is published on pages 8½" x 11" (ad size, 7"x10") and produced by photooffset, except that printed sheet advertising may be inserted and bound in with the magazine in most cases. The closing date for any issue is approximately the 10th of the month preceding. If possible, the company advertising should produce final copy. For photooffset, the copy should be exactly as desired, actual size, and assembled, and may include typing, writing, line drawing, printing, screened half tones, and any other copy that may be put under the photooffset camera without further preparation. Unscreened photographic prints and any other copy requiring additional preparation for photooffset should be furnished separately; it will be prepared, finished, and charged to the advertiser at small additional costs. In the case of printed inserts, a sufficient quantity for the issue should be shipped to our printer, address on request.

Display advertising is sold in units of full pages (ad size 7" by 10", basic rate, $170) and half pages (basic rate, $90); back cover, $330; inside front or back cover, $210. Extra for color red (full pages only and only in certain positions), 35%. Two-page printed insert (one sheet), $290; four-page printed insert (two sheets), $530. Classified advertising is sold by the word (50 cents a word) with a minimum of ten words. We reserve the right not to accept advertising that does not meet our standards.

5. Rate Change. Commencing January 1, 1955, the rates will change to the rates stated above. The old rates will apply until March 1 to advertising contracts received before December 1.

6. Who are our advertisers? Our advertisers in recent issues have included the following companies, among others:

The Austin Co.
Automatic Electric Co.
Burroughs Corporation
Federal Telephone and Radio Co.
Ferranti Electric Co.
Ferroxcube Corp. of America
General Ceramics Corp.
Hughes Research and Development Lab.
International Business Machines Corp.
Ketay Manufacturing Co.
Laboratory for Electronics
Lockheed Aircraft Corp.
Logistics Research, Inc.
Monrobot Corp.
Potter Instrument Co.
Raytheon Mfg. Co.
Reeves Instrument Co.
Remington Rand, Inc.
Sprague Electric Co.
Sylvania Electric Products, Inc.
Telecomputing Corp.

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